GLOBAL AND LOCAL PROCESSING OF HIERARCHICAL PATTERNS IN HIGH-FUNCTIONING AUTISTIC CHILDREN -- A TEST OF WEAK CENTRAL COHERENCE THEORY

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Abstract

The theory of weak central coherence in autism suggests that autistic individuals have the tendency to have relatively local information processing rather than a wholistic one. The aim of the present study was to investigate the global and local processing of hierarchical patterns with variations of exposure duration and display size of stimuli in autistic children, so that the refined hypotheses derived from the weak central coherence theory could be verified. In order to have a comprehensive understanding of the underlying information processing, the eye-movement patterns in performing letter and object search tasks were also recorded. Results revealed that neither global nor local advantage was shown in both autistic and control groups. However, a greater local-to-global interference was found in autistic group. In regard to eye-movement, the autistic children tended to have fewer fixations in the designated areas and to have "diffuse" fixations. It implies that autistic children are more susceptible and less inhibited to react to local information, and have a diffuse searching strategy in performing search-tasks.

摘要

「中央整合理論」(Weak Central Coherence Theory) 指出自閉症的人組織零碎的訊息的能力比較弱。換言之，他們較難受整體的意思影響，反之只會留意或詮釋其中的一些部份。因此是次旨在研究自閉症兒童接收及辨認整個圖案與其部份的分別，並與一般兒童作出比較，藉此驗証該理論。爲對自閉症兒童訊息處理過程有更深入的了解，另一個研究更用儀器將兒童眼球停留的位置及時間紀錄下來，用以分析兒童在尋找目標時眼睛移動及停留的模式。結果顯示自閉症及一般兒童均沒有對整體或個別資料有較快的反應，自閉症兒童則較一般兒童更受個別資料的干擾。眼球移動的研究指出自閉症較難隨意地控制眼睛停留在指定的位置內，及用較分散的方法找尋目標。

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CHAPTER ONE

INTRODUCTION

Empirical observations show that autistic individuals tend to have certain peculiar behaviors, such as persistent preoccupation with parts of objects (a diagnostic criteria in DSM-IV, 1994), insistence on sameness, and good rote memory. Kanner (1943) described that they were unable to experience wholes without full attention to the constituent parts and they perceived objects as incomplete if parts of them were altered. The theory of central coherence recently proposed by Frith (1989) is intended to account for the peculiar behaviors displayed by autistic individuals under the paradigm of information processing.

Weak Central Coherence Theory

The term "central coherence" refers to "a characteristic of normal information processing describing the tendency to draw together diverse information to construct higher-level meaning in context." (Frith, 1989; Frith & Happe, 1994) Frith (1989) suggested that autistic individuals tend to have a weak rather than a strong central coherence in information processing. According to the weak central coherence theory, autistic individuals have the tendency to ignore the contextual information and to have relatively local rather than wholistic information processing.

According to the weak central coherence theory, autistic individuals are predicted to have better performance in the tasks that require detailed processing, but poorer in those that demand recognition of global meaning. Shah and Frith (1983) suggested that the weak central coherence theory may account for the specific talents and deficits in autism shown in the past studies. Frith & Hermelin (1969) found that the impairment of autistic children might consist of a failure to make use of complex information or to integrate information from different sensory modalities. Hermelin

& O'Connor (1967) conducted testing on memory capability and found that the effect of structure and contextual restraints affected the recall in autistic groups less than that in control groups. Tager-Flusberg (1991) reported that autistic children were comparable to control groups in recalling unrelated lists but poorer in semantic related lists. Both studies suggest that autistic people are less able to use linguistic knowledge to facilitate information retrieval. With regard to the facial recognition studies, autistic people show superior ability in the recognition of upside-down faces instead of upright faces (Langdell, 1978; Hobson, Ouston & Lee, 1988). This indicates that autistic individuals might benefit in a lesser extent from the meaningful information of upright faces. All of the above studies imply that the autistic people tend to be less capable to utilize or integrate the diverse local information to form a higher level meaning.

Several recent studies have attempted to test the weak central coherence theory by comparing the performance of autistic and control groups on different tasks which, ranging from perceptual to high-level sentence reading, involve various levels of information processing and cognitive functioning (Happe, 1994; 1997; Shah & Frith, 1993; Jolliffe & Baron-Cohen, 1997). The results of the studies show that there is conflict in the theory of weak central coherence.

Child Embedded Figure Test (CEFT) is a complex design test with several hidden figures embedded in a larger meaningful object and requires the subjects to identify those figures. Shah & Frith (1983) conducted the test with autistic children and found that they had more accurate performance than the control group. Jolliffe & Baron-Cohen's (1997) replicated the study with some modifications. They used the standard adult Embedded Figure Test (EFT) and the reaction time as the performance index. The clinical groups (i.e. subjects with autism and Asperger syndrome) revealed shorter reaction time than the normal control group. However, Brian & Bryson (1996) were unable to replicate the superior performance of autistic children on the similar task.

Jolliffe & Baron-Cohen's (1997) study showed that autistic subjects demonstrated some preference for local structures to global one in a drawing task based on the Rey Figure, which is a complicated geometric figure with local details. However, no statistically significant difference between the performance of autistic and control groups was actually found.

The unusual profile of Wechsler Intelligence Scale of autistic people has also received much attention because their performance among different subtests varies greatly. This finding is obtained from autistic people of all ages and ability levels (Shah & Frith, 1993). Happe (1994)'s review showed there is a peak of performance on the Block Design subtest in the performance scale and a trough on the Comprehension subtest of the verbal scale in most of the profiles of the autistic subjects. Happe (1994) inferred that the weak central coherence theory might account for the peak performance of Block Design.

Several researchers have investigated the manifestation of weak central coherence in a higher level of processing by inviting autistic people to read homograph in sentences with contextual meaning (Frith & Snowling, 1983; Happe, 1997). Frith and Snowling (1983) found that autistic children showed less correct pronunciation of homographs. Happe (1994) noted that their pronunciation benefited significantly less from preceding context of the sentences. The results further support the existence of weak central coherence in autistic individuals, who are less able to utilize and integrate the linguistic context to derive the correct meaning and pronunciations of the homographs.

Superior Spatial Hypothesis

The theory of weak central coherence can be further elaborated to formulate more refined hypotheses which might explain the performance of autistic individuals on certain tasks. The first hypothesis is the superior spatial hypothesis, which suggests that autistic individuals have better spatial ability. This hypothesis seems to account for the superior performance of autistic people on EFT and the Block Design subtest. Shah and Frith (1993) studied the performance of autistic people on a modified Block Design task with systematic variations, including the effects of segmentation, rotation and obliqueness. The result revealed that autistic subjects had more superior performance than the control group provided that the presentations of the whole designs were not pre-segmented. The mental segmentation in this task is the main cause of difficulty in block design test. Therefore, pre-segmented condition might facilitate the task performance of control subjects and the discrepancy of performance on two groups would then disappear. Shah and Frith (1993) deduced that the superiority of autistic individuals in the task could not be presumably explained by their superior spatial ability as there were no significantly differential effects of rotation and obliqueness conditions on the autistic and control groups. However, it is argued that the absence of differential effects on two groups might be due to the ceiling effects of the two conditions. Therefore, the superior spatial hypothesis could not be definitely ruled out by Shah and Frith (1993)'s negative findings.

Superior Segmentation Hypothesis

The second hypothesis is the superior segmentation hypothesis, which suggests that autistic individuals might be faster in segmenting complex patterns or information into their constituent components than normal population. The hypothesis appears to account for the superior performance of autistic individuals in both the Embedded Figure Test (Jolliffe & Baron-Cohen, 1997) and the Block Design subtest of the Wechlser Intelligence Scales (Frith & Snowling, 1988; Shah & Frith, 1993).

Global Precedence Hypothesis

The third hypothesis, called the global precedence hypothesis, focuses more on the availability of information of whole structures relative to local ones in autistic individuals. This hypothesis proposes that individuals with autism might lack global precedence (Navon, 1977). Global precedence is defined as the tendency that "the global structure is available in the percept earlier than local features are"(pp. 43) and this characteristic is inherent in the information processing of normal people. It is hypothesized that the processing of global structure of the autistic individuals is not faster than that of that of normal people. Their superior performance on the EFT and the Block Design might be explained by their lack of global precedence. Since global percepts are not available earlier than local ones, autistic people are less interfered by the global percept in analyzing the local information

Compared with the first two hypotheses, the third hypothesis, global precedence hypothesis, focuses on the perceptual processing, which is at a more fundamental level of information processing.

Perceptual Span Hypothesis

In addition to the three hypotheses, another hypothesis, named as perceptual span hypothesis, is proposed to explain the performance of autistic individuals on the above studies. The perceptual span or span of apprehension refers to the span of the stimulus or the amount of materials which can be processed from a briefly presented visual display (Neals, 1971; Ester & Taylor, 1964). It is suggested that the autistic individuals might have a narrower perceptual span, so that they tend to have relatively local information processing rather than global one. In other words, it is hypothesized that autistic people process less amount of information from the one eye-fixation point than the normal individuals. The narrower the perceptual span of autistic individuals, the more focus on piecemeal information and less affected by wholistic information than normal individuals.

Main Study--Global and Local Processing Study

The aforementioned empirical studies, which investigate the weak central coherence theory, examine the performance of autistic and control groups on the performance of complex tasks with certain manipulations. Most of the tasks involve complex information processing related to a complex range of cognitive functions, such as visual motor coordination, visual perceptual analysis, organization, etc. In order to tease out and identify the specific deficits of autistic people in processing information, the present study examines a relative fundamental level of information processing. Among the hypotheses propounded above, the perceptual span and global precedence hypothesis is firstly verified since it involves relatively basic levels in information processing than the other two hypotheses.

In order to verify both perceptual span hypothesis and the global precedence hypothesis, this study replicated with some modifications the classical experiment of Navon (1977) which investigates the global precedence in normal population. Navon (1977, Experiment 3) proves the inevitability of the global precedence in normal population by using a Stroop-like task. Subjects were presented stimuli with hierarchical patterns, which were large letters made up of small letters, either H or S. There were three types of stimuli in the experiment. The first one was the consistent stimuli which was large letters made up of identical small letters. The second was the conflicting stimuli which was large letter H constituted of small letter Ss or vice versa. The last one was the neutral stimuli which was large letters H or S made up of small rectangulars. Subjects were instructed to attend to global structure (global-directed) or local parts (local-directed) and performed the discrimination task with reaction time as the performance index. Results showed that responses to the global patterns were faster than to the local parts. In addition, the global-to-local interference was demonstrated when the subjects were attending to local features. However, no local-to-global interference occurred when they were processing global configuration. Navon (1977) suggested that these findings support the inevitability of global precedence in information processing.

In reviewing the previous studies of global and local processing of autistic individuals, Mottron & Belleville (1993) (cited in Jolliffe & Baron-Cohen), and Ozonoff et al. (1994) replicated Navon's (1977) experiment. However, their findings gave contradictory results. Motton and Belleville (1993) conducted the experiment with a 34-year-old male autistic patient who had superior ability in three-dimensional drawing of inanimate objects (savant syndrome). He showed a global-advantage effect similar to normal controls. The advantage effect is found by comparing errors at the local and global levels for congruent stimuli. However, he also demonstrated a local interference effect, which was indicated by the errors made in the incongruent stimuli under the influence of one level to the other level. In contrast, Ozonoff et al. (1994) failed to demonstrate the local interference effect in their study. Similar to Navon's experiment, a large letter made up of small letters (H, S or X) was presented to three groups, who were high functioning autistic children, children with Tourette Syndrome, and normal children. The procedure was the same as Navon's study in which subjects were instructed to respond to either the large letters or the small constituent letters and their reaction times were recorded. However, no significant difference was found among different groups. It was concluded that the autistic group demonstrated neither difficulties in global processing nor superiority in processing local details in the study.

There might be several possible reasons to explain the contradictory results in the two studies. Firstly, the difference in the exposure time should be taken into consideration (Jolliffee and Baron-Cohen, 1997). In Mottron's and Belleville's study, the exposure time was 10-25 millisecond, whereas the exposure time in Ozonoff's (1994) study was 1000 milliseconds. Kimach (1992) stated that the interference pattern between the global and local letters was affected by exposure duration. With the longer exposure duration, the local processing was favored and the bi-directional interference effects might happen.

Secondly, the constituent elements of global structure may also be an important factor affecting the global and local processing. In Ozonoff et al 's (1994) study, the contour of the large letters were made up of two to three letters, whereas in Navon's (1997) experiment it was composed of only a single letter. As Navon (1981) suggested, the concurrent presence of neighboring elements would inhibit the processing of the elements that are close to each other. This sensory phenomenon is called lateral masking. Given such a phenomenon, the processing of the constituent components in Ozonoff et al's (1994) experiment would be inhibited. The processing of local features might be less favored than that of the global structure.

Furthermore, it is proposed that the number of individual components made up the global configuration might affect global and local processing. Martin (1979) reported that when a global letter was made up of fewer components using Hs and Ss as stimuli, local precedence was indicated. In Ozonoff et al's (1994) study, the number of components in large letters was more than that in Navon's (1997) study. The large letters in Ozonofff et al's (1994) experiment were made up of 12 components vertically and 10 elements horizontally whereas the large letters in Navon's (1977) study were made of 7 components and 6 components respectively. Because of the large number of constituent components in large letters, Ozonoff et al's (1994) experiment tended to favor local processing.

The contradictory results in the previous studies make it a worthwhile attempt to replicate Navon's (1997) experiment. Based on the global precedence hypothesis, it is predicted (1) autistic subjects tend to lack global precedence or to have local precedence, whereas the control subjects show global precedence and (2) the autistic subjects are likely to have a weaker global-to-local interference or to have a stronger local-to-global interference than the control group.

With reference to the perceptual span hypothesis, the amount of stimuli processed within a fixation is determined by two factors, namely the speed of processing in one fixation (temporal factor) and the area of effective visual field (spatial factor). As mentioned before, autistic individuals are believed to have narrower perceptual span than control ones. It is suggested that they process less amount of information within a fixation. Varying the two factors of perceptual span, exposure duration of the presentation of stimuli and the display size of stimuli, may have differential effects on the performance of autistic and control group on the global-local discrimination task. It is predicted that autistic subjects might have poorer performance than control subjects in the condition during which stimuli are presented with shorter exposure duration and larger size. In addition to the reaction time, the error rate and within subject variability are also recorded as performance indices, so that the underlying deficits of autistic persons might be captured in different measures.

Eye Movement Study

Since the global and local processing study only focuses on investigating the relationship of global and local information in two groups based upon performance, there is a lack of direct evidence from the recording of scanning strategies of two groups in that study. The information of scanning patterns is essential and important for interpreting the performance of two groups in the global and local processing. In addition, such information is relatively more fundamental for information processing. It would be useful to show a more comprehensive picture about the information processing of autistic children.

O'Connor and Hermelin (1967a) empirically showed that autistic children may not scan their external environment in the same way as retarded and normal children. Analysis of their data revealed that the autistic children spent less time focusing on one of the visual displays looking through a peephole in a viewing box. Instead, the autistic children spent much of their time looking at the inside of the viewing box. Since eye movements and the direction of each child's visual focus were recorded manually by an observer, such a methodological problem made the study unable to ensure that eye movement and fixation were recorded accurately. Therefore, any conclusions could not be strongly confirmed in that study.

The present study made a worthwhile attempt to record the eye-movement pattern of autistic and control group in performing certain visual search tasks in order to better understand the encoding processing stage of the two study groups. The findings of this study would be useful in interpreting the findings of the main study. In order to improve the reliability of the present study, an instrument, called EyeLink system, were utilized to collect the information about the process of visual scanning.

Purposes of the Present Study

In summary, the purposes of the study were to test the global precedence hypothesis and perceptual span hypothesis by investigating the differences between two groups on global and local processing. The latter two hypotheses were examined by manipulating two variables: (1) size of stimuli, and (2) exposure duration. The study also explored the difference between autistic and control groups on the eye movement patterns, which might indicate the encoding process of two groups.

CHAPTER II

GLOBAL AND LOCAL PROCESSING STUDY--METHOD

Participants

High-functioning autistic subjects, who were diagnosed as suffering from autism by both child psychiatrists and clinical psychologists, were recruited from the Department of Child Psychiatry in hospitals to voluntarily participate in a series of experiments in the present study. They were autistic children aged from 6 to 14 and had the score of non-verbal intellectual functioning, measured by Raven's Standard Progressive Matrix (Raven's), above 80. A total of 25 high-functioning autistic children participated in the experiment. They studied either Grade 3 to Grade 6 in the mainstream primary schools or Form 1 to Form 2 in the mainstream secondary school in Hong Kong.

The 25 children in the control group were selected from two mainstream primary schools and one mainstream secondary school. They were individually matched with 25 autistic children in terms of age (within the range of –6 and +6months), gender, and non-verbal intellectual functioning (Raven's score) (within the range of –5 and +5). All the subjects had normal or correct-to-normal vision.

All of 25 high-functioning autistic children and 25 normal controls participated voluntarily in the experiment. The mean age of autistic children and children in control group was 11.7 (SD=1.35) and 11.5 (SD=1.34) respectively. The mean Raven's score of children in autistic group and control group was 96.92 (SD=14.22) and 96.64 (SD=14.35) respectively.

Apparatus and Setting

Visual stimuli were presented on a 800 x 600 256 color monitor. Since the present study intended to improve the accuracy of display time of stimuli and of measuring subjects' reactions, the presentation of stimuli and data collection were controlled by a computer with software called DMASTER. A cordless mouse and a cordless keyboard were connected to the computer and used to control the presentation of stimuli, so that any disturbances caused by the experimenter could be minimized. A response box with two buttons was linked to the computer to collect responses from participants. The luminance of the monitor and of the room was set at the most optimal level.

Subjects sat comfortably at a distance of 50 cm from the monitor. A headset was used to minimize any head movement or any change in visual angles relative to the stimuli. The headset fixed subjects' eyes in a position which was horizontal with the centre of the monitor. In order to minimize distraction, a large white board was applied to hide all the computer apparatus except the screen and the response box. The walls in the room were covered with a piece of plain-colored cloth.

Stimuli

All of the stimuli presented in this experiment were letters, which was composed of smaller ones. There were only three letters, namely "H", "S" and "X", presented in this experiment. Same as Navon's (1977) experiment, these letters was constructed into three configurations as consistent, conflicting and neutral (See Figure 1). In the consistent condition, a large letter was made up of identical small letters as the large one. A large "H" was made up of smaller "H"s, or a large "S" constituted smaller "S"s. In the conflicting condition, a large letter consisted of smaller non-identical letters. The configurations were a large "H" composed of smaller "S"s, or a large "S" made up of smaller "H"s. In the neutral condition, either a large "H" or "S" was composed of smaller "X"s, or a large "X" was constructed from smaller "H"s or "S"s.

The size and exposure duration of stimuli was manipulated in this experiment.

There were two sizes for the structure of stimuli, (a) small (about 6 cm x 5 cm) and (b) large (about 18 cm x 15 cm). The sizes of the constituent letters were about 0.6 cm x 0.5 cm and 1.8 cm x 1.5 cm for two stimuli respectively (See Figure 1). The visual angles of large structures were 6.87° x 5.72° and 20.41° x 17.06° respectively. The "large" ones were actually three times of the size of the "small" ones. The number of constituent components of the stimuli was held constant in the two stimuli of different sizes.

With regard to exposure duration, half of the stimuli were presented with duration of 65 milliseconds and another half was displayed for duration of 130 milliseconds.

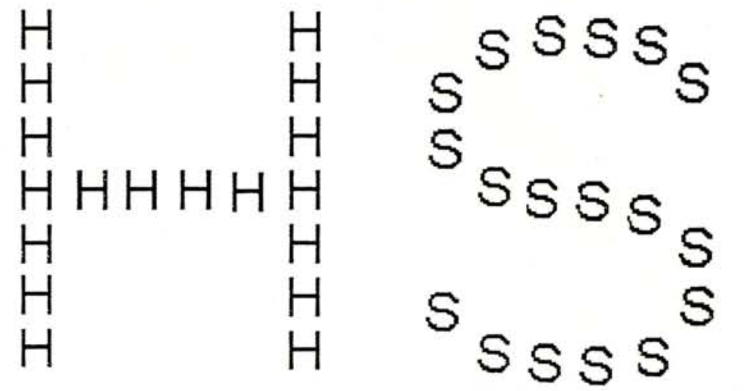
Design and Procedure

The experiment for each subject was divided into two sessions. In each session, either the global-directed or the local-directed instruction was given to the subject. In the global-directed instruction, subjects were instructed to attend to the global and large structure of the stimuli only. In the local-directed condition, they had to focus on the local and constituent letters of the stimuli. Subjects were required to identify and respond to, according to the instruction, either the global structure or the local letters, by pressing the correct keys marked with the corresponding letters, either "H" or "S", on the response box. Both speed and accuracy were emphasized in the instruction.

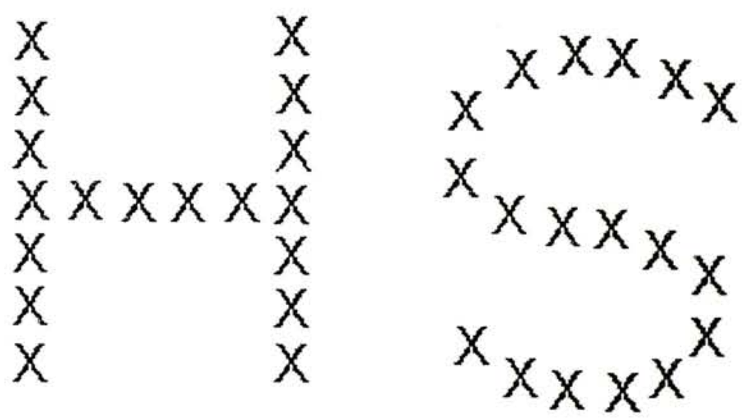
At the beginning of each session, a thorough explanation was firstly given in order to make sure the subjects to understand which pattern and which part of the stimuli to attend to, that is either global or local structure. The series of patterns shown in one trial was displayed one by one slowly. In the meantime, the experimenter gave instruction and described the sequence of patterns. Having

Figure 1. Different Types of Stimuli Presented in the Global and Local Processing Study

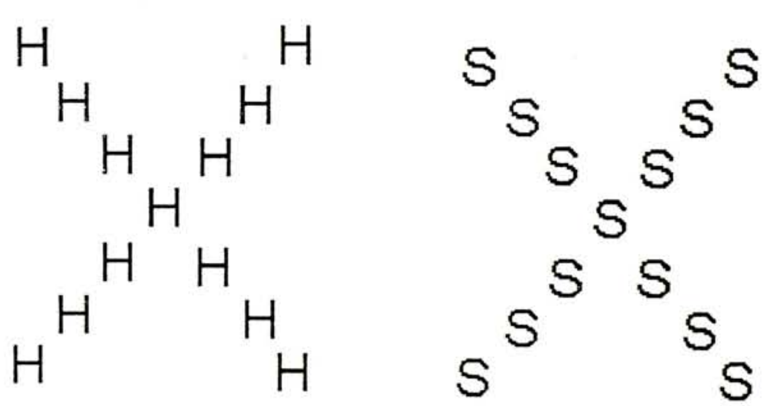
Consistent stimuli (for both global- and local- directed instruction)



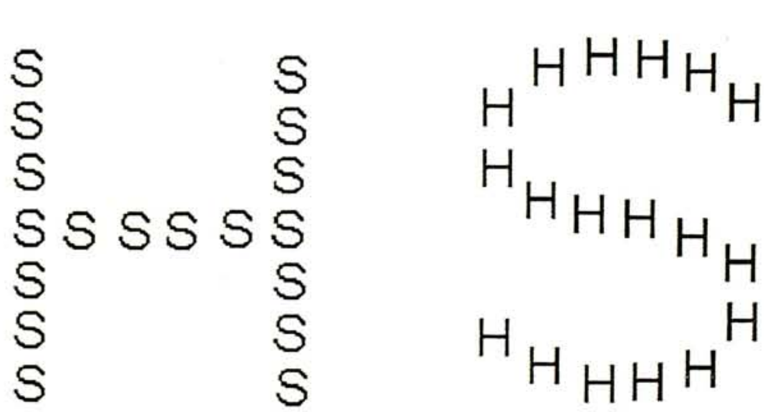
Neutral stimuli (for global-directed instruction only)



Neutral stimuli (for local-directed instruction only)



Inconsistent stimuli (for global- and local- directed instruction)



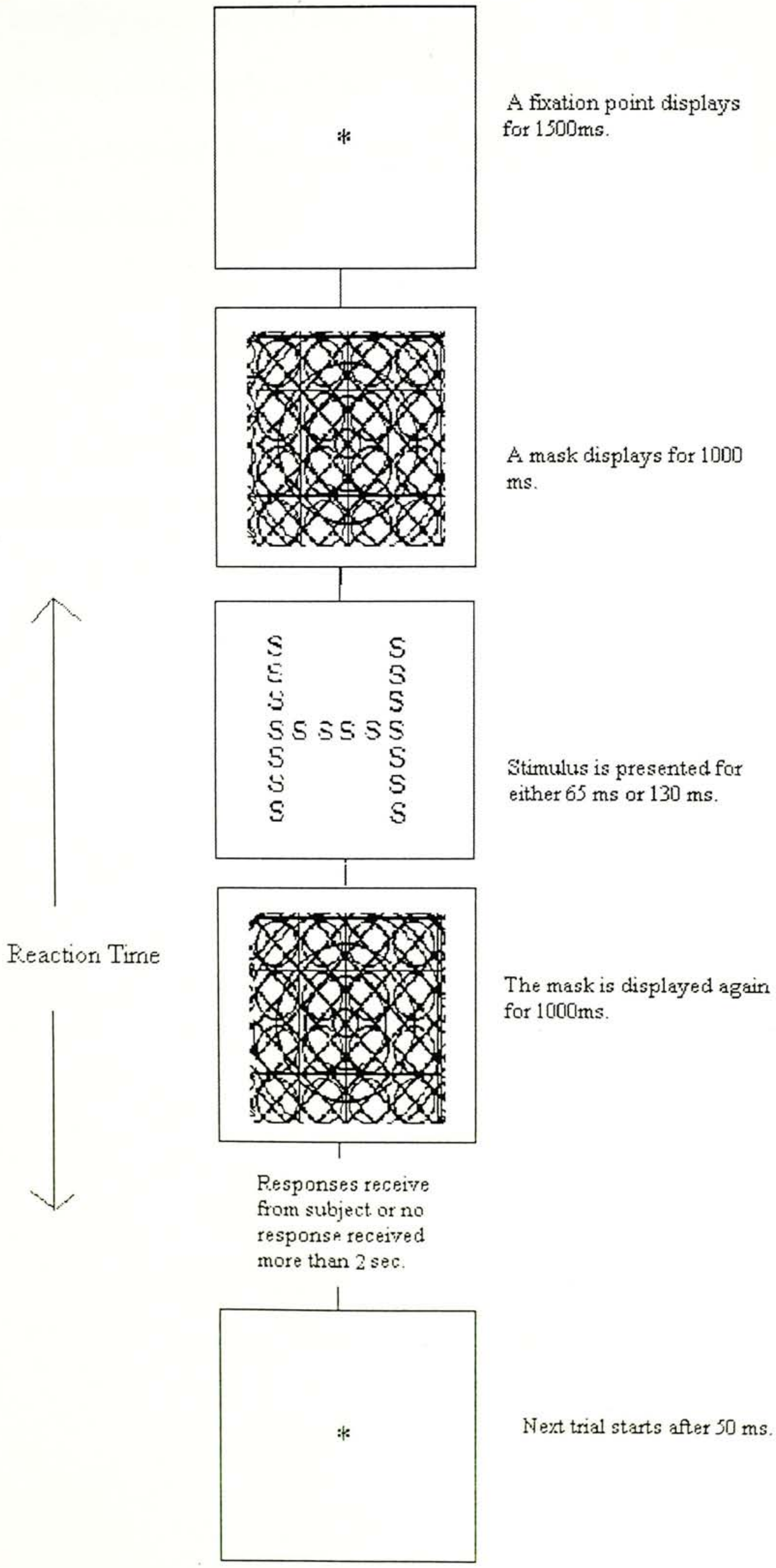
delivered response to the trial, the subject was given feedback. When the explanation had been finished, there was a run of ten practice trials without any feedback given. Then, test trials began.

At the beginning of each trial, a fixation point (*) at the centre of the monitor was presented for about 1500 ms. (See figure 2) A pattern with many grid lines of different orientations and circles of different sizes displayed for about 1000 ms. as a mask. The stimulus was then shown at the centre of the monitor. Exposure duration for each stimulus was either 65 or 130 milliseconds. The stimulus would then be masked by the pattern shown before. After subject had given response by pressing a key, the next trial would start at 50 ms later. If no responses were received in 2 seconds, that trial was recorded as missing and the next trial would be presented. Both the reaction time and the error were recorded. The reaction time was the time interval between the stimulus displayed and response received from subject. No feedback was given to subjects in the test trials.

In each set of instruction (either global-directed or local-directed), a total of 48 trials were administered. There were four types of trials involving stimuli of two different sizes ("small" and "large") and two exposure duration (65 and 130 ms.) in each set of instruction. The four types of trials were small-size/65ms., small-size/130ms., large-size/65ms., and large-size/130ms. Each type of trials consisted of one of three kinds of stimuli that were either consistent, neutral or conflicting. The order of 48 trials was randomized and then divided into four blocks. After finishing one block, subjects were allowed to take a rest for about 15 seconds. Then the next block started.

After one of two sets of instructions (global-directed vs. local-directed) was completed, a one-minute break was given to the subjects. The other set of instruction

Figure 2 Procedure of a trial



would then be given. The experimental procedure was the same as before. An illustration of a run of ten practice trials, and eventual run of 48 test trials were given. The order of the two sets of instruction (global-directed and local-directed) was counter-balanced among subjects. A total of 96 trials were administered altogether in the experiment.

CHAPTER III

GLOBAL-LOCAL PROCESSING STUDY--RESULTS

Before the data was analyzed, those responses lied on the extreme ends was discarded from the data set based on certain criteria. For the lower bound of reaction time, it was common to use the cutoff at 180 milliseconds. Since people have a physiological limit on the speed to react to a visual stimulus, any reaction time less than 180 ms is too fast to be a real measure of reaction time. In the present data set, a total of 8 responses (0.167% of total responses) was below 180 ms and excluded in the following analysis.

With reference to the upper end, responses which were too long to be considered as genuine reaction time were also removed from the data set. A rule usually adopted to detect outliers was applied to determine the upper cutoff point. Any reaction time which was 3 S.D.s above the mean reaction time was also deleted from the data set. 34 responses (0.708% of total responses) were above the upper cutoff and were taken out from the data set.

Age and IQ

There were no significant differences on age and Raven's score between the autistic and control groups (See Table 1).

Speed-Accuracy Trade Off

There was no significant correlation between mean reaction time and percentage of errors in both autistic subjects [$r = -0.146$, n.s.] and control ones [$r = 0.128$, n.s.]. No speed-accuracy trade off was thus evident in the present study.

Performance Indices

There were three performance indices, (a) the reaction time, (b) the percentage of errors, and (c) the within-subject variability of reaction time, in the present study.

Table 1:

Mean age and Ravens's scores of subjects participated in the global-local processing study

	Autistic N=25		Control N=25		
	M	(SD)	M	(SD)	t-value
Age	11.7	(1.35)	11.5	(1.34)	0.553
Raven's score	96.92	(14.22).	96.64	(14.35)	0.069

*p<0.05; **p<0.01; *** p<0.001

Only reaction times of the correct responses were included in the data set for the following analyses. Another performance index was the percentage of errors, which were defined as false-positive responses. Those missing responses (more than 2 seconds) and correct responses above the upper cutoff and below the lower cutoff were not counted as errors. Within-subject variability of reaction times was defined as the mean standard deviation of reaction times.

The means and standard deviations for three performance indices in all experimental conditions were shown in Appendix 3, 4 and 5.

Analyses Testing Global Precedence Hypothesis

Analyses Testing Group Difference On Global/Local Precedence

A series of two-way MANOVA (repeated measure) analyses with a within-subject variable, instruction (globally- vs. local-directed) and a between-subjects variable, group (autistic vs. control) on three performance indices were run.

Reaction time. In the present result, there was no main effect for instruction [$F(1,48)=2.888$, n.s.] and group [$F(1,48)=1.396$, n.s.] and no interaction effect between group and instruction on reaction time was revealed [$F(1, 48)0.866$, n.s.] (See Table 2). The results suggest that no significant difference between the reaction times under global-directed and local-directed instructions in both autistic and control group. It implies that neither global precedence nor local precedence is revealed in both autistic and control groups. The hypothesis, which assumes that the availability of local information to autistic subjects tends to be faster than that of normal controls, is not supported.

Percentage of errors and within subject variability of reaction time. No significant interaction effects of group and instructions were revealed on percentage of errors [$F(1,48)=0.013$, n.s.] (See Table 3) and mean standard deviation of RT

Table 2

<u>Mean and Standard Deviation of Reaction Time on Two Types of Instruction and Two Subject Groups (Reaction times in ms)</u>

	Autistic N=25		Control N=25	
	M	(SD)	M	(SD)
Global-directed instruction	711.35	187.19	676.27	153.18
Local-directed instruction	696.84	191.98	625.75	154.51

Table 3

Mean and Standard Deviation of Percentage of Errors on Two Types of Instruction and Two Subject Groups (%)

	Autistic N=25		Control N=25	
	M	(SD)	M	(SD)
Global-directed instruction	12.58	12.81	6.83	8.60
Local-directed instruction	10.67	11.70	4.50	4.15

[$F(1,48)=0.205$, n.s.] (See Table 4) were found. However, there was a significant group difference on percentage of errors [$F(1,48)=7.792$, $p<0.05$] and variability of RT [$F(1,48)=5.337$, $p<0.05$]shown in the analyses. It suggests that the performance indicated by percentage of errors and variability of RT of autistic group was poorer than control group in both two sets of instructions. In other words, autistic subjects made significantly more errors and had greater variability of RT than control group in performing those tasks in both sets of instruction. Neither poorer performance of autistic group in global-directed instruction nor better performance of autistic group in local-directed instruction than that of control group was evident in the results. The prediction of differential effect of two sets of instructions on two groups was not supported.

Analyses Testing Group Difference on Global-To-Local Interference

In order to test the hypothesis of group difference on global-to-local interference, only those responses under the local-directed instruction were selected for the following analyses. Two-way MANOVA (repeated measure) analyses with a within-subject variable, types of stimuli (consistent vs. neutral vs. conflicting) and a between-subject variable, group (autistic vs. control) were performed on three performance indices as previous analysis.

Reaction time (RT). Neither main effect for group [$F(1,48)=2.030$, n.s.] nor interaction effect of group x types of stimuli [$F(2,96)=0.780$, n.s.] was significant. However, a significant main effect for types of stimuli on RT was revealed [$F(2,96)=19.021$, $p<0.001$]. (See Table 5) A planned comparison showed that the above significant effect of types of stimuli on RT was mainly contributed by the difference between RT of neutral and conflicting ones [$F(1,48)=22.503$, $p<0.001$] (See Figure 3). Results suggested that global-to-local interference existed for both autistic and control group. However, no evidence supported the hypothesis that autistic subjects had a weaker global-to-local interference than control.

Percentage of errors and within-subject variability. Congruent with the results of RT, there was no significant interaction effect on percentage of errors [$F(2,96)=0.531$, n.s.] and on mean standard deviation of RT [$F(2,96)=0.597$, n.s.] shown in the results (See Table 6 and 7). Running planned comparisons on interaction effects of group with three types of stimuli were conducted and no significant effects were found among them in both performance indices.

Significant main effects for types of stimuli on errors [$F(2,96)=5.191$, $p<0.01$] and on variability of RT [$F(2,96)=4.988$, $p<0.01$] were revealed. Similar to the result indexed by RT, the significant effect of types of stimuli on percentage of errors and variability of RT were mainly contributed by the difference between neutral and conflicting ones [$F(1,48)=9.938$, $p<0.01$ and $F(1,48)=9.312$, $p<0.01$ respectively] (See Figure 4 and 5). The results suggested that the global-to-local interference, which was also indicated by the percentage of errors and variability of RT, was found in both autistic and control group.

Analyses Testing Group Difference on Local-To-Global Interference

In this series of analyses, those trials given in the global-directed instruction were included, so that the local-to-global interference on two groups could be investigated. A series of two-way MANOVA (repeated measure) analyses with a within-subject variable, stimuli (consistent vs. neutral vs. conflicting) and a between-subject variable, types of group (autistic vs. control) on performance indices were done.

Reaction time (RT). There was no group difference on RT [$F(1,47)=0.812$, n.s.].

Table 4

Mean and Standard Deviation of Within subject Variability of Reaction Times on Two Types of Instruction and Two Subject Groups (%)

	Autistic N=25		Control N=25	
	M	(SD)	M	(SD)
Global-directed instruction	186.22	53.72	154.35	50.67
Local-directed instruction	182.51	51.08	157.19	47.19

Table 5

Mean and Standard Deviation of Reaction Time on Types of Stimuli and Two Groups (Reaction times in ms)

	Autistic		Control	
	M	(SD)	M	(SD)
Local-directed instruction				
Types of stimuli				
Consistent	663.71	(169.48)	608.73	(161.10)
Neutral	689.40	(205.40)	606.10	(135.10)
Conflicting	739.59	(217.73)	665.85	(188.10)

Figure 3 : Types of Stimuli Plot Against Group on Reaction Time (Local-directed Instruction)

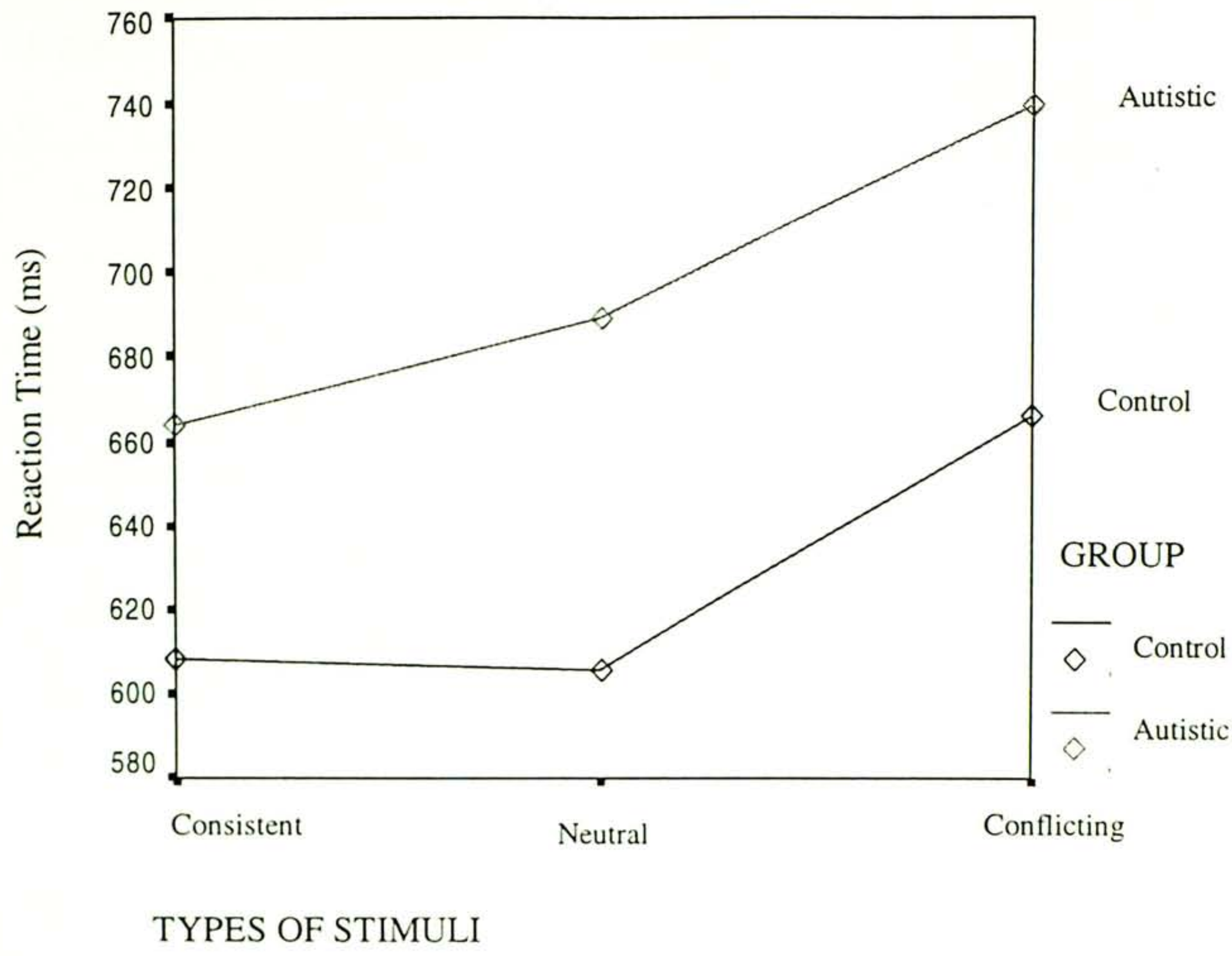


Table 6

Mean and Standard Deviation of Percentage of Errors (%) on Types of Stimuli and Groups

	Autistic		Control	
	M	(SD)	M	(SD)
Local - directed instruction				
Types of stimuli				
Consistent	1.79	(2.30)	0.50	(0.96)
Neutral	1.42	(2.25)	0.54	(0.80)
Conflicting	2.12	(2.02)	1.21	(1.33)

Table 7

Mean and Standard Deviation of Variability of Reaction Time on Three Types of Stimuli and Two Subject Groups (Variability of Reaction Time in ms)

	Autistic		Control	
	M	(SD)	M	(SD)
Local- directed instruction				
Types of stimuli				
Consistent	173.39	(84.52)	135.68	(51.25)
Neutral	160.41	(61.32)	135.63	(50.17)
Conflicting	187.18	(52.77)	172.81	(76.77)

(See Table 8) Significant differences were only found among different types of stimuli [$F(2,94)=33.244$, $p<0.001$]. Even though interaction effect between stimuli (consistent vs. neutral vs. conflicting) and group was only marginally significant [$F(2,94)=2.682$, $p=0.74$], the interaction effect between stimuli (consistent vs. neutral) and group [$F(1,47)=5.654$, $p<0.05$] was significant in the planned comparison analysis. Nevertheless, the interaction effect between stimuli (neutral vs. conflicting) and group was insignificant [$F(1,47)=0.545$, n.s.] (See Figure 6). The overall interaction effect (stimuli x group) was attributed to comparison involving stimuli (consistent vs. neutral) and group. The results suggested that autistic subjects had a greater improvement indicated by RT than control group in the consistent condition when comparing with the neutral and conflicting conditions. It suggested that the performance of autistic subjects was facilitated by local elements which were identical with the global one. This supported the prediction that the local-to-global "interference" in autistic group was stronger than that in control group.

<u>Percentage of errors and variability of reaction time.</u> Results revealed a significant interaction effect of group and stimuli on the percentage of errors [$F(2,96)=5.025$, $p<0.01$] (See Table 9) but insignificant on the variability of RT [$F(2,94)=1321$, n.s.] (See Table 10). Planned comparison showed that the significant interaction effect on errors was contributed by the significant interaction effect between two types of stimuli (neutral vs. conflicting) and group [$F(1,48)=6.985$, $p<005$]. (See Figure 7) A series of t-tests comparing the group difference on three types of stimuli suggested that autistic subjects made significantly higher percentage of errors than control ones in the conflicting stimuli only [$t(48)=2.297$, $p<0.05$]. The performance of autistic subject, indexed by error rate, deteriorated from consistent

Table 8

Mean and Standard Deviation of Reaction Time on Three Types of Stimuli, and Two Subject Groups (Reaction times in ms)

	Autistic N=24		Control N=25	
	M	(SD)	M	(SD)
Global- directed instruction				
Types of stimuli				
Consistent	655.40	(166.53)	644.24	(160.41)
Neutral	731.79	(214.15)	668.59	(153.41)
Conflicting	771.51	(213.17)	720.68	(156.84)

Figure 4: Types of Stimuli Plot Against Group on Percentage of Errors (Local-directed Instruction)

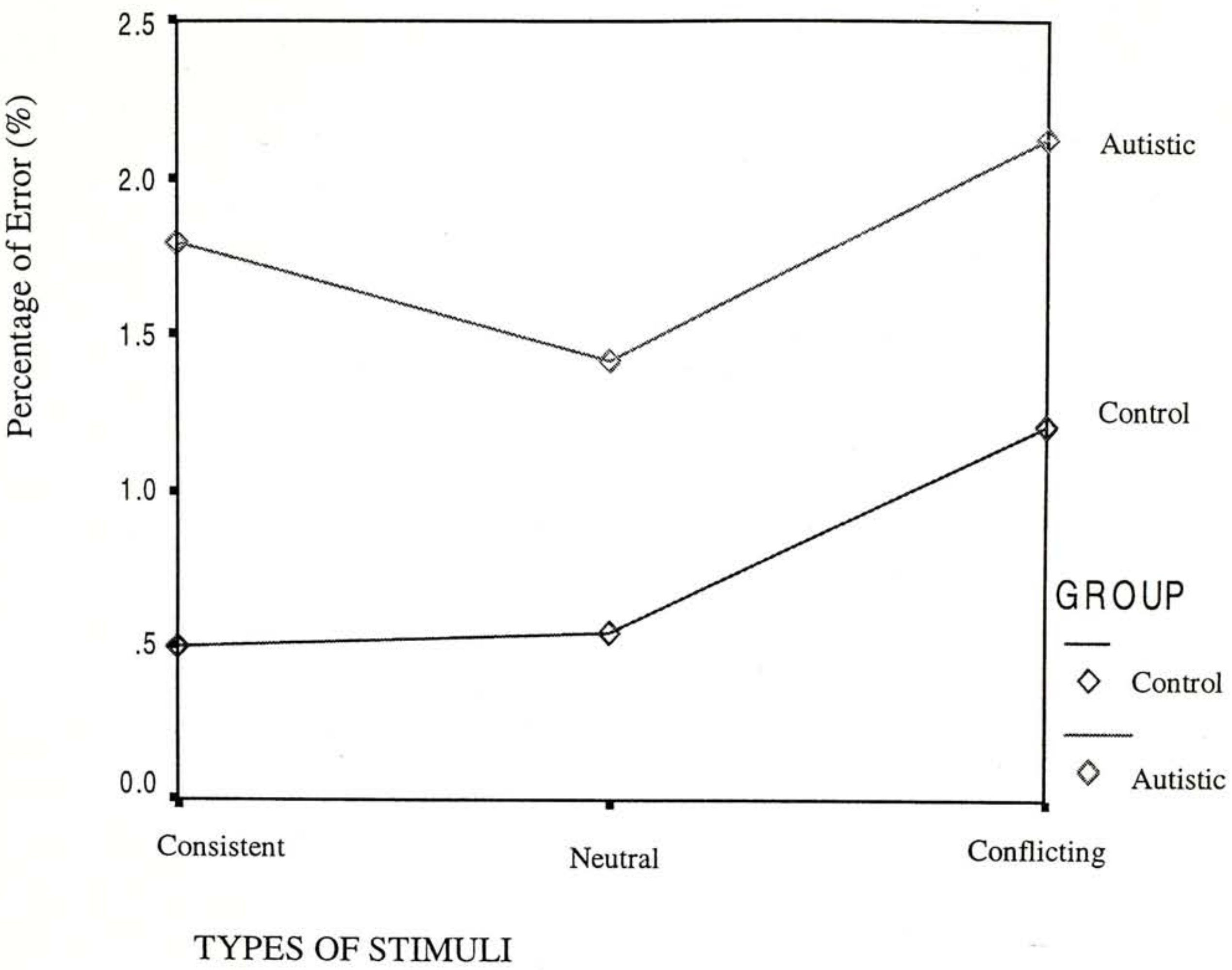


Figure 5: Types of Stimuli Plot Against Group on Mean Standard Deviation of Reaction Time (Local-directed Instruction)

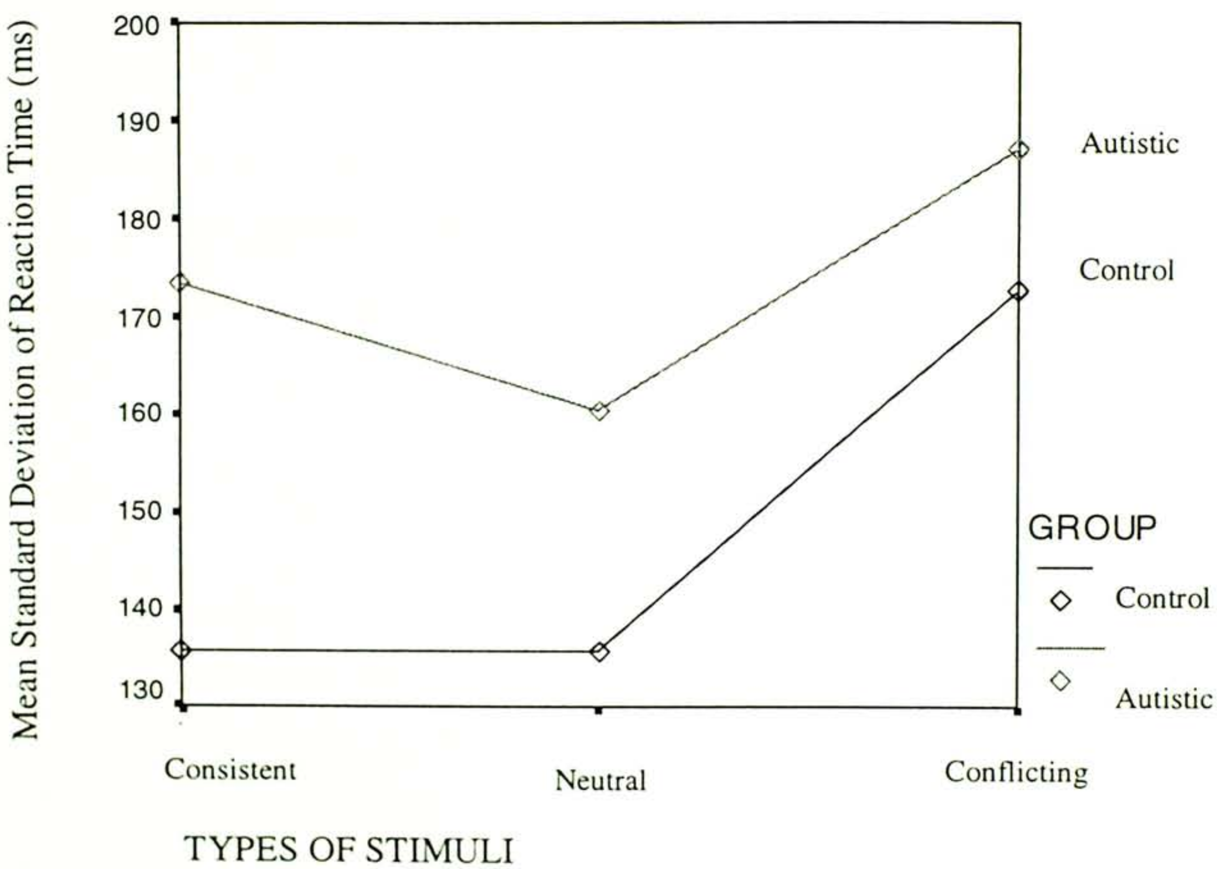


Table 9

Mean and Standard Deviation of Percentage of Errors (%) on Three Types of Stimuli and Two Subject Groups

	Autistic N=25 M	(SD)	Control N=25 M	(SD)
Global- directed instruction				
Types of stimuli				
Consistent	1.083	(1.74)	0.63	(1.08)
Neutral	1.21	(1.64)	0.96	(1.31)
Conflicting	4.00	(4.07)	1.83	(2.37)

Table 10

Mean and Standard Deviation of Variability of Reaction Time on Three Types of Stimuli and Two Subject Groups (Variability of Reaction Time in ms)

	Autistic N=24 M	(SD)	Control N=25 M	(SD)
Global- directed instruction				
Types of stimuli				
Consistent	164.85	(56.84)	131.86	(56.98)
Neutral	185.81	(60.92)	141.54	(65.29)
Conflicting	182.04	(65.37)	167.41	(77.77)

Figure 6 : Types of Stimuli Plot Against Group on Reaction Time (Global-directed Instruction)

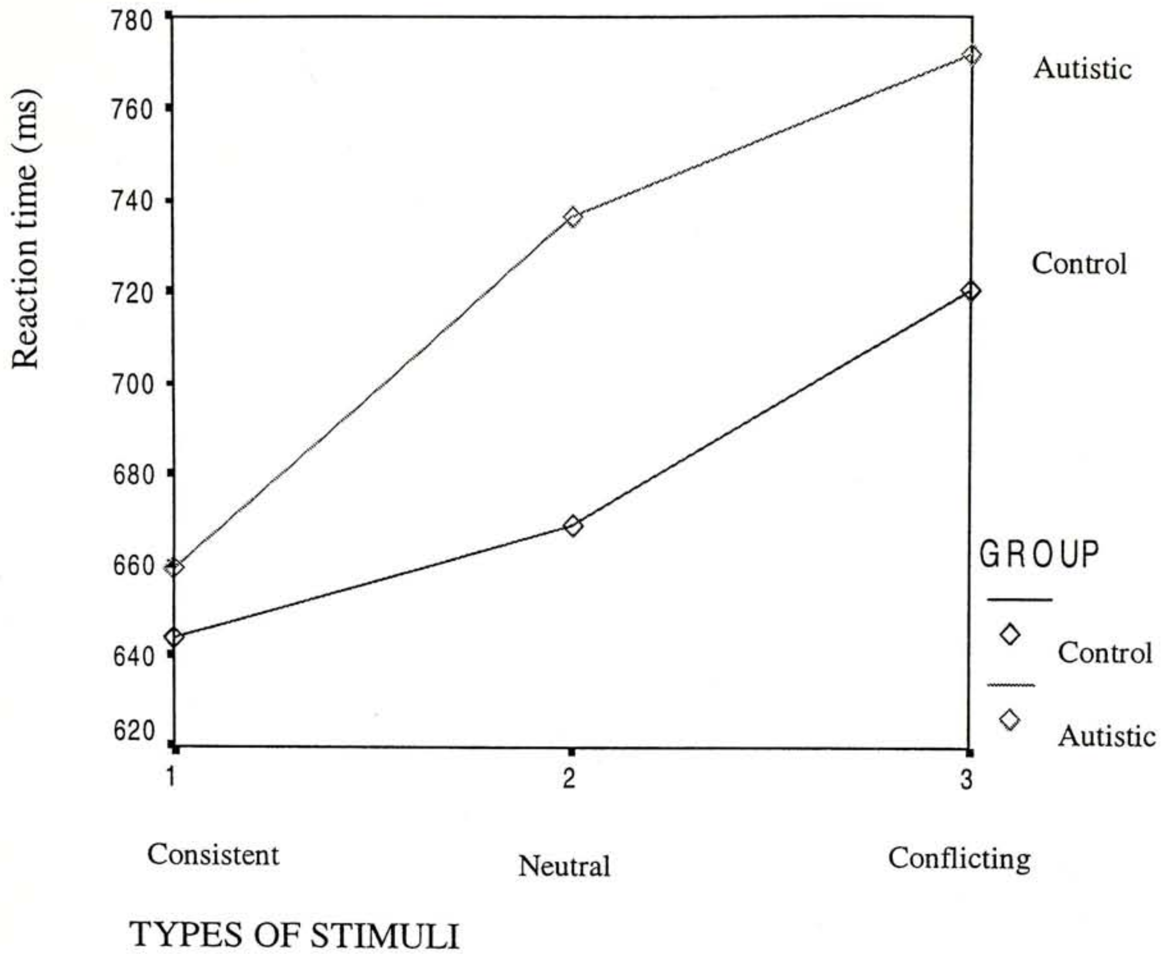
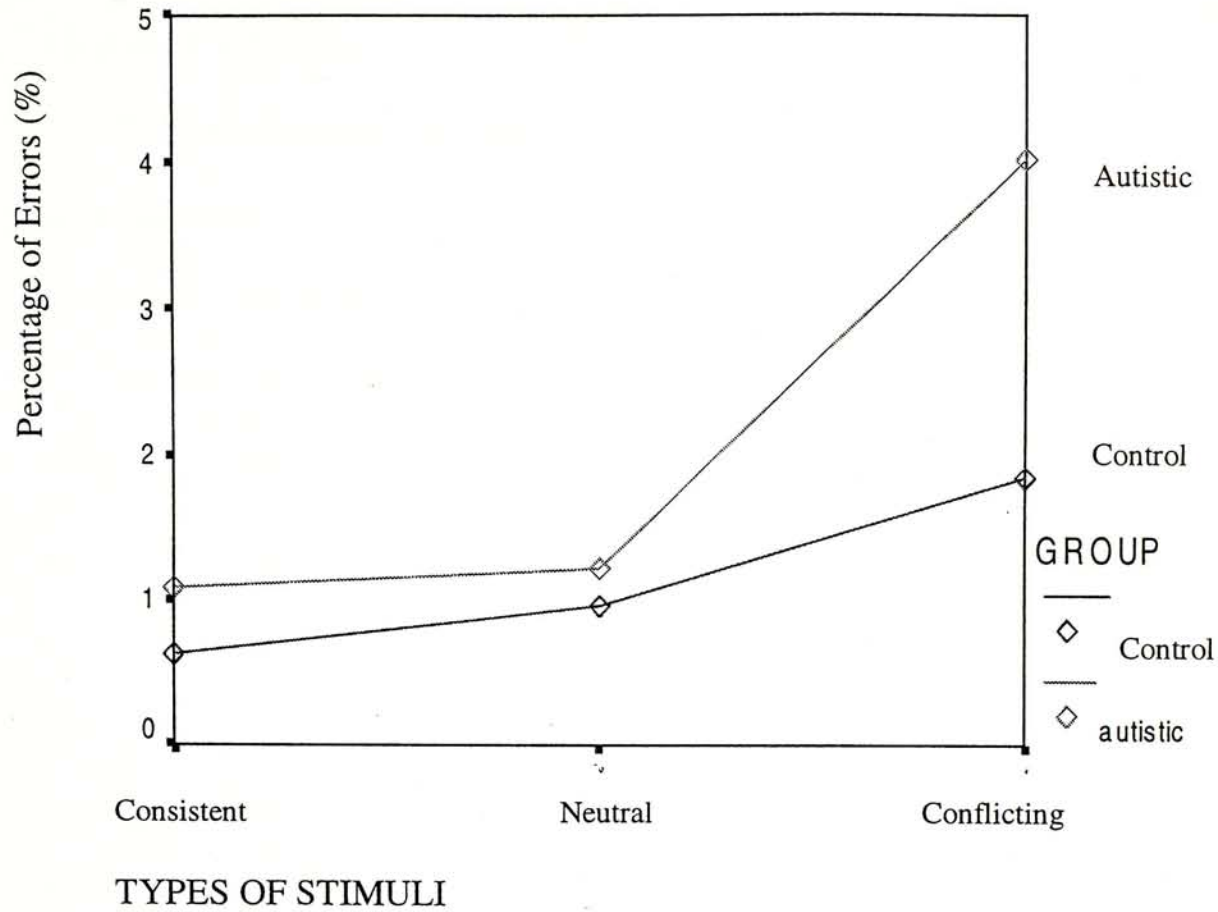


Figure 1: Types of Stimuli Plot Against Group on Percentage of Errors (Global-directed Instruction)



and neutral conditions to conflicting one was more than that of control group. Presence of conflicting local elements in the stimuli had induced more errors in the autistic group than the control one. This implied that autistic subjects tended to be more interfered by local information when attending to the group structure. This supports the hypothesis of greater local-to-global interference that was reflected from a higher rate of errors of autistic group than normal control.

Similar to previous analyses, main effect for group on variability of RT was significant [$F(1,47)=4.165$, $p<0.05$] whereas that on the percentage of error was marginally significant [$F(1,48)=3.473$, $p=0.68$] (See Figure 8). It suggested that the autistic subjects had higher percentage of errors and greater variability of RT than control group across three types of stimuli (consistent, neutral and conflicting).

Analyses Testing The Perceptual Span Hypothesis

With regard to the testing of the perceptual span hypothesis, a three-way MANOVA (repeated measure) with two within-subject variables, (1) size of stimuli (i.e. "small" and "large"), and (2) exposure duration (i.e. 65 ms and 130 ms) and between-subject variable, types of group (autistic and control) were run on three performance indices separately.

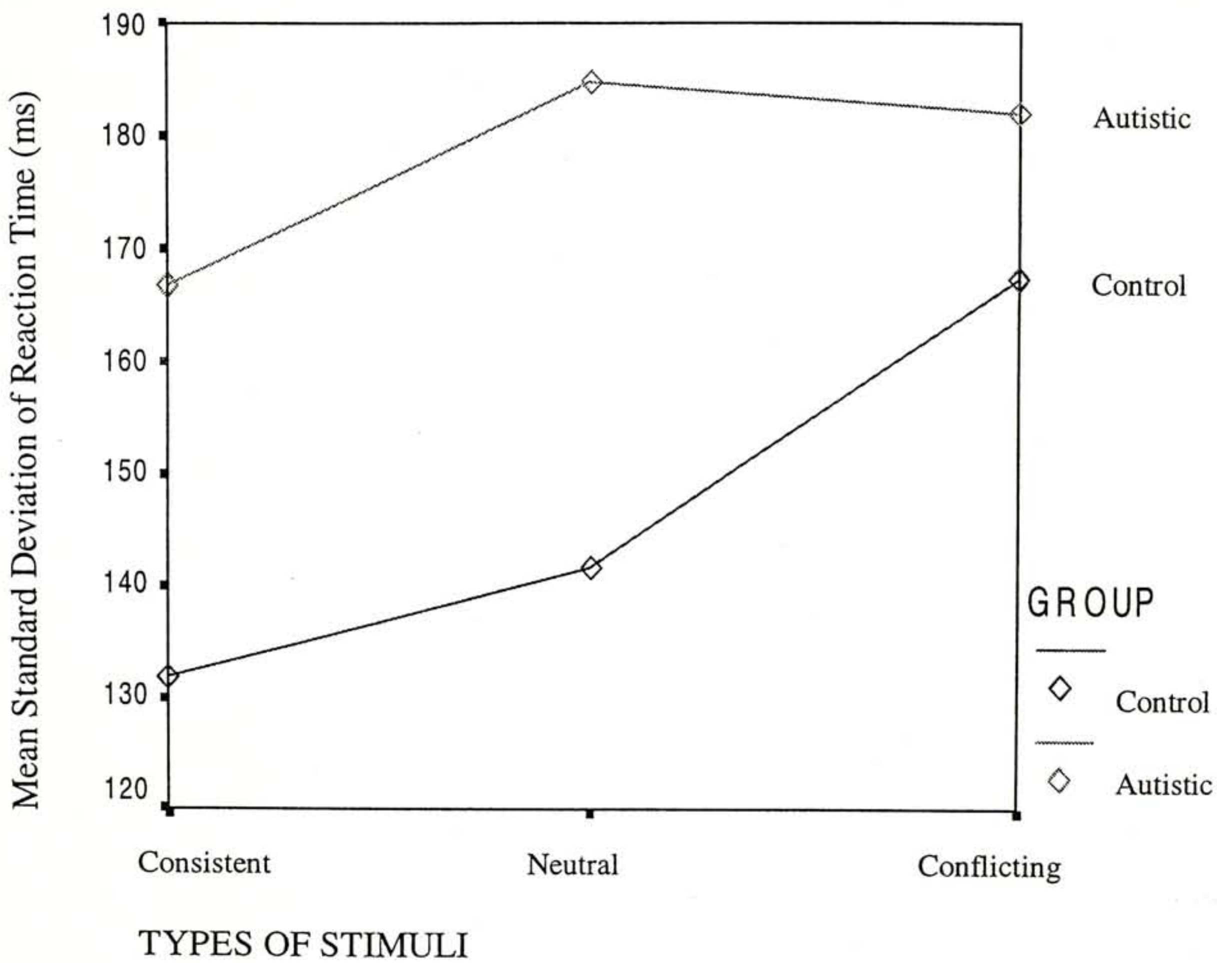
Reaction time. Results revealed that there was no significant main effect for group, and interaction effects of size x group, exposure duration x group and size x exposure duration x group (See Table 11). It suggested that manipulating size, exposure duration or both of them did not have any differential effect on autistic and control group in RT. Significant differences were only found in main effect for size [$F=7.477$, $p<0.01$] and interaction effect of size and exposure duration [$F=7.813$, $p<0.01$] on RT. Both groups had significantly longer RT in stimuli of "small" size than those of "large" size. The significant interaction effect also suggested that

Table 11

Mean and Standard Deviation of Reaction Time on Size, Exposure Duration and Groups (Reaction times in ms)

	Autistic		Control	
	M	(SD)	M	(SD)
Exposure Duration: 65ms				
Size				
Small	728.14	(196.00)	665.90	(155.86)
Large	692.50	(178.18)	637.85	(146.06)
Exposure Duration: 130 ms				
Size				
Small	698.06	(168.33)	649.52	(141.50)
Large	695.15	(155.33)	652.13	(150.33)

Figure 8: Types of Stimuli Plot Against Group on Mean Standard Deviation of Reaction Time (Global-directed Instruction)



changing from duration of 65 ms to duration of 130 ms induced a decrease in RT in the "small"-size stimuli but not in the "large"-size ones for both autistic and control groups.

Percentage of errors and within-subject variability of reaction time. All interaction effects with group (i.e. size x group, exposure duration x group, and size x exposure duration x group) two performance indices were insignificant. (See Table 12 and 13) Consistent with the results of RT, the present results generally did not support the perceptual span hypothesis.

Table 12

Mean and Standard Deviation of Percentage of Errors (%) on Size, Exposure Duration and Subject Groups

	Autistic		Control	
	M	(SD)	M	(SD)
Exposure Duration: 65ms				
Size				
Small	3.33	(3.14)	1.46	(1.78)
Large	2.54	(2.31)	1.25	(1.38)
Exposure Duration: 130 ms				
Size				
Small	2.79	(2.88)	1.21	(1.52)
Large	2.966	(2.38)	1.75	(2.10)

Table 13

Mean and Standard Deviation of Variability of Reaction Time on Size, Exposure Duration and Group (Variability of Reaction Time in ms)

	Autistic		Control	
	M	(SD)	M	(SD)
Exposure Duration: 65ms				
Size				
Small	206.15	(74.96)	173.63	(57.32)
Large	186.95	(51.75)	156.23	(41.53)
Exposure Duration: 130 ms				
Size				
Small	184.67	(55.49)	161.71	(60.03)
Large	201.30	(64.52)	159.65	(56.51)

CHAPTER IV

GLOBAL AND LOCAL PROCESSING STUDY – DISCUSSION

Results revealed that there was no differential effect of global-directed and local-directed instructions on all the three performance indices (RT, the percentage of error and the within-subject variability of RT) on autistic and control groups. No evidence in the present study supports either global precedence or local precedence effect.

Both groups showed global-to-local interference in terms of all performance indices. There was a lack of evidence supporting a weaker global-to-local interference in autistic group when the group was compared with the control one. Local-to global interference was revealed in both groups on all the performance indices. However, autistic group showed a greater local-to-global "interference" in RT and the percentage of error but not in the variability of RT. Therefore, part of the present findings support the global precedence hypothesis.

With regard to the perceptual span hypothesis, the manipulations of size and exposure duration did not induce any differential effect on two groups among three performance indices. There is no evidence supporting the perceptual span hypothesis in the present study.

Besides the predictions of two hypotheses, the results also showed that the percentage of error and variability of reaction time of autistic subjects were generally greater than that of control group across different conditions.

Implications of Incompatible Findings with Pervious Studies

In the previous studies of global-local processing (Navon, 1977), normal adults exhibited both global advantage (i.e. faster responses to global structure than local elements of hierarchical patterns) and global-to-local interference only. However, normal children in the present study did not show global precedence. They showed

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In the previous studies of global-local processing (Navon, 1977), normal adults exhibited both global advantage (i.e. faster responses to global structure than local elements of hierarchical patterns) and global-to-local interference only. However, normal children in the present study did not show global precedence. They showed an absence of global advantage and both global-to-local and local-to-global interference. Based on the results of faster responses to global patterns than elements in adult subjects, Navon (1977) interpreted that "global processing is a necessary stage of perception prior to more fine-grained analysis". Deviated from the previous studies, the insignificant difference between reaction times of global and local information implies that information in both levels might be processed in a parallel way with competitive speed instead of a hierarchical or sequential way. In other words, the global and local information was available to subjects at the same time.

Following the argument of non-hierarchical processing, since both levels of information are available at the same time, the presence of both global-to-local interference and local-to-global interference in both groups may suggest that subjects could not restrict their attention to the specific level of information without being aware of the other level. In other words, they could not "turn off" the channels of recognition of both type of information. Nevertheless, the next question is what made the global and local processing of the normal controls in the present study different from previous studies. The developmental change of global and local processing may be a possible answer to the question.

Elkind, Koegler, and Go found that (cited in Whiteside, Elkind & Golbeck, 1976), there is a developmental change in the part-whole perception in normal children. Children below 6-years-old tend to report seeing only parts whereas children above age of 6 begin to report seeing both parts and wholes. However, children aged between 6 and 8 tend to report wholes and parts in a sequential, non-hierarchically integrated way. Only the children above 8 years old tend to report the figures in a hierarchical relationship. In the previous researches of global and local studies of hierarchical patterns, most of the subjects were normal adults (Navon, 1977; Miller, 1981; Martin, 1979; Luna, 1993). However, in there present study, the mean age of normal controls was 11.5. Their age ranged from 9.1 to 14.0. The present finding may be interpreted in terms of developmental change because some of the subjects might not be old enough to appreciate the hierarchical relationship of global and local information. Therefore, global pattern and local element were not recognized in a hierarchical but in a separated and parallel way.

<u>Implications of Evidences Supporting the Global Precedence Hypothesis</u>

With regard to the global precedence hypothesis, results indicated that global-directed and local-directed instructions did not have differential effect on two groups. In addition, both groups showed global-to-local interference under the local-directed instruction. However, when the subjects were required to attend to global structure only, autistic subjects tended to be more frequently either facilitated or interfered by the local elements in terms of RT and the percentage of errors. The hypothesis is not totally supported in the present findings.

The present results are consistent with Motton and Belleville's(1993) study which found global advantage as normal controls but a local interference in a 34 years-old autistic man. Motton and Belleville (1993) concluded that autistic subject lacked of global precedence because of the opposite direction of findings. The present study further confirmed that the characteristic of autistic subjects was only manifested as local-to-global interference but not as global/local advantage effect.

In the previous research, two indicators, both global advantage and global-to-local interference, of "global precedence" were demonstrated in the global-local processing of normal adults. The absence of differential effect of global and local instructions on two groups and a greater local-to-global "interference" in autistic group neither support the "global precedence" nor totally support the "local precedence". There are several possible interpretations for the inconsistent findings in the present study. Firstly, the sensitivity of the present experiment might not be high enough to differentiate two groups in a consistent way. Secondly, the results might be viewed as two separate indicators of "global/local precedence". The manipulation of types of instructions and types of stimuli (consistent, neutral and conflicting) actually captured different abilities in the information processing. The manipulation of types of instructions served to investigate the relative availability of two types of information in two groups (advantage effect) whereas manipulating the types of stimuli revealed the ability of disregarding the irrelevant information available in hierarchical patterns (interference effect).

Concerning the issue of separated indicators, the inability to induce differential effect of global and local instructions could possibly be explained from a developmental perspective. The developmental change of the global and local processing mentioned before may also reasonably explain the present results. As the mean age of control subjects was 11.5, the age of normal controls in this experiment was relatively too young to possess the characteristic of inevitable availability of global information which was usually found in normal adults. Instead, young control subjects tended to attend to both global structure and local components without an asymmetrical dominance. Since the global and local processing was expected to be less "global-dominant" in normal children than normal adults from a developmental perspective, manipulating global and local instructions was therefore unable to exert significantly differential effects on autistic children and normal controls in the present study. This might be furthered explained by the two contradictory studies about global and local processing of autistic people. Motton and Belleville (1993) reported that the conflicting stimuli were unable to exert any global precedence and a local interference effect on a 34-years old male with autism and savant syndrome. However, Ozonoff et al's (1994) performed an experiment to a group of autistic and normal children but were unable to explain the lack of global precedence and local interference. The contradictory results might be related to the age difference of subjects in two studies.

The difference between two groups may be explained by the stronger local-to-global interference in autistic group. When attending to the global structure, the autistic children may be less capable to ignore the local information or to have a greater preference over local information than the control group. Since the findings suggested that both levels of information were available at the same time to both groups, the presence of both global-to-local and local-to-global interference can be interpreted by the fact that both levels of information are equally accessible to and mutually affect each other. However, the autistic group was not only more frequently interfered by local information (higher percentage of errors under global-directed instruction in conflicting stimuli), but also benefited more extensively from local constituted elements than the control group (shorter RT under global-directed instruction in consistent stimuli). One explanation may be that the autistic children were more susceptible or vulnerable to local information and therefore easier to evoke a response. Another interpretation is that they probably had a higher preference over local information. The former explanation suggests that autistic children tend to have some incapability to avoid the influence of local information. The latter one describes a cognitive style of autistic children. However, if susceptibility to local information was only a cognitive style instead of a deficit of autistic children, it would be more likely to have a facilitating rather than impeding effect. Therefore, the present findings of both types of effects may support the interpretation of susceptibility to local information.

Regarding sensitivity, there were one between-subject variable (group) and four within-subject variables (types of instructions, types of stimuli, size and exposure duration) in the experiment design of the present study, and so the different hypotheses could be verified. In consideration of the limited attention span of children, only 4 trials for each specific condition of each subject were conducted. In addition, the global and local processing was shown to be affected by many factors, such as the relative and absolute size of global structure and local components, visual angles, exposure duration and lateral masking (Martin, 1979; Navon & Norman, 1983; Luna, 1993; Luna, et al, 1995). Besides this, there was an inadequacy in the studies of autistic individuals in global and local processing. Therefore, the manipulations of within-subject variables in the present study might not tap on the differences between two groups in global and local processing and thus may not effectively differentiate the performance of two groups. Since the present experiment appeared not to be very sensitive, the conclusions could not be definitely drawn from the present findings.

<u>Interpretation of Perceptual Span Hypothesis</u>

With reference to the perceptual span hypothesis, the manipulations of size and exposure duration did not have differential effect on two groups. The findings generally do not support the perceptual span hypothesis. No evidence supported the difference between autistic and control groups in the amounts of information processed in one fixation.

CHAPTER VI

EYE-MOVEMENT STUDY -- METHOD

Participants

Participants in the present study were selected from the same subject pool of the global-local processing study. As the recording of eye movement patterns of people with glasses was less accurate, those subjects wearing glasses were excluded in the eye movement study. Consequently, 12 participants in the autistic group and 8 children in the control group were excluded in the present study. Refusing to wear the headband of the instrument, three autistic children and one child in the control group failed to perform the tasks. As a result, only 12 out of 25 autistic children and 16 out of 25 children in control group could accomplish all of assigned tasks. The mean age of autistic group was 11.7 (SD=1.10). Their mean Raven's score was 99.83 (SD=17.08). The mean age of control group was 12.0 (SD=1.23) and the mean score of Raven's was 96.13 (SD=15.48).

Materials

Two letter-search tasks and two object-search tasks were presented to each subject. In both letter-search tasks, a page with a target letter and a test page, which consisted of six rows and 21 columns of letters, were shown (See Figures 9a, b and Figure 10a, b). The target letters for two letter-search tasks were D and Z respectively. In each test page, there is only one target letter (either D or Z) amongst the 125 non-target letters, all of which were in angular shapes, for example, W, V, F, T, etc. Searching target letter D was relatively easier than searching letter Z as the former had prominent feature of curvature, which was distinct from other non-target ones with angular features.

Two object-search tasks were adopted from Illinois Test of Psycholinguistic

Figure 9a: Letter searching task: Task letter D

Figure 9b. Letter searching task: Searching page (Letter D)

M N V T W W T N V X T W M T N V H F H M T

M N W F W M N W T T N M F F V V F H L N X

M K M L M X V L X V M N X K T X N X V H H

W T F H H V W W H V L H M W M L L V F M F

W W F M V K H T N K K W L H N T W M X H N

N V H L T T V D V N X N K H W M T X T W H

Figure 10a: Letter searching task: Target letter Z

Figure 10b: Letter searching task: Searching page(Letter Z)

TMNWMKFMLTVKLNHVTNWHM

HTHMTHMTXMNWTTNMFMTMM

MWFVMXVLXVMHKKNFNVTNK

FNXKTXNXVHHWTFHHVVLXF

VNNVMLLVLHNTWMNVHLNFX

FNXHNNVHMFHTKKTZNXKHV

Abilities (ITPA) and modified in this study. Two sets of pictures, which consisted of a picture of target object and a test picture, were selected from ITPA. In the object-search tasks, there were 11 bottles and 10 dogs as target objects partially hidden in two test pictures respectively (See Figure 11 a, b and 12a, b respectively). The shapes of hidden target objects in the test picture were not the same and bore no similarities to that shown in the picture of the object target. The original version of those tasks in ITPA was a paper and pencil task. The present study utilized a computer to present the pictures. Part of the pictures was cut off and their sizes were modified in order to fit into the screen.

Apparatus

The EyeLink System, which consisted of three components, a headband, an EyeLink subject computer, and an EyeLink operator computer, was used in this experiment. The experimenter put the headband on the heads of the subjects. The eye-cameras and head camera on the headband were adjusted to record eye movements of subjects. The EyeLink subject computer presented the search tasks. The EyeLink operator computer is a control unit for the record of eye movements. A joy-pad was linked to the computer to control the presentation of materials.

Design and Procedure

After the calibration of eye movements of the subject was accomplished, the experimenter started the search tasks by pressing a key on the joy-pad. Half of the subjects were assigned to begin with the two letter-search tasks and then the two object-search tasks. The order of the tasks was reversed for the other half. The orders of two trials in each type of search task were counter-balanced.

Figure 11a: Object searching task: Target object (Bottle)

Figure 11b: Object searching task: Searching page(Bottle)

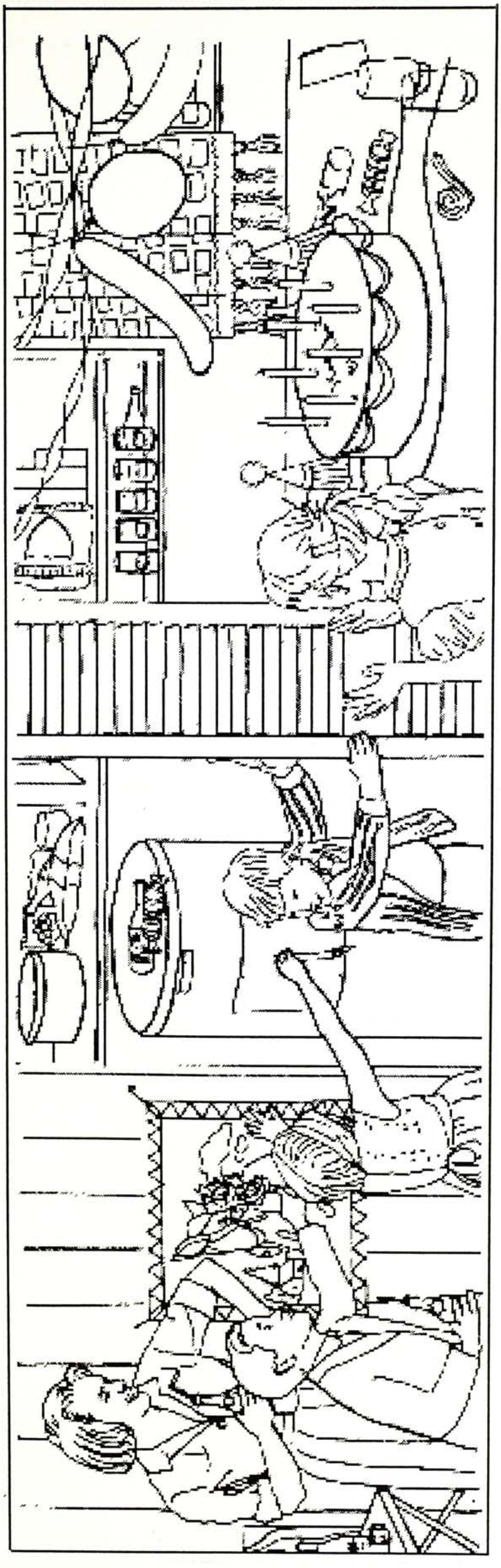


Figure12a: Object searching task: Target object (Dogs)

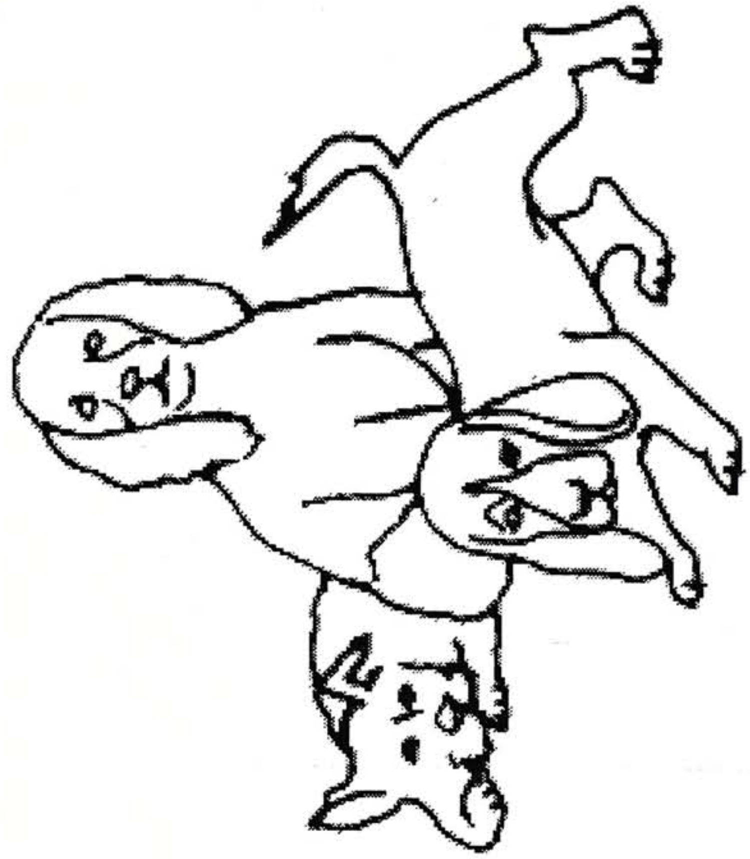
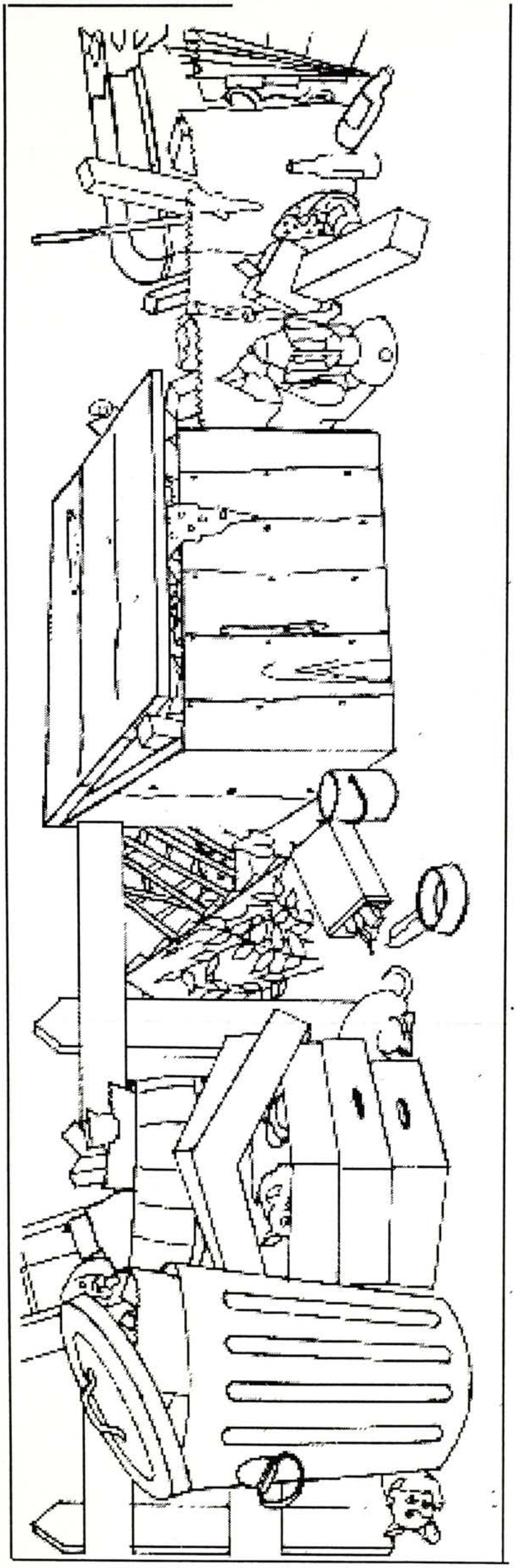


Figure 12b: Object searching task: Searching page (Dogs)



In the letter-search tasks, a target letter, either D or Z, was displayed at the centre of the monitor. Subjects were instructed to name that letter and to find out that letter in the following test page which consisted of several rows of letters. Before the test page was displayed, subjects were reminded to search the target letter from left to right and row by row. In order to avoid any interference on the record of eye movements, subjects were not allowed to point out the target letter until they were told to do so. Once they found the target letter, they had to remember its location and tell the experimenter that they had found the target letter. The experimenter would press a key on the key-pad to stop recording eye movements and display the same page of letter again. Subjects were allowed to point out the target letter at that time. Then next the search-task started.

The procedure of object-search tasks was similar to that of letter-search tasks. Target object(s) appeared at the centre of the screen and then subjects were asked to name the object. Different from the instruction in the letter-search tasks, subjects were instructed to find out all the objects, which were partially hidden in the following test pictures. They were reminded that the hidden objects might be more than one and the shapes of objects were not exactly the same as the target object displayed before. They were also not allowed to point at the target objects until they finished searching. When subjects told the experimenter that they had found all the target objects, the record of eye movement stopped and the target objects were pointed out one by one and recorded by the experimenter on a recording sheet.

Two experimenters were present in this study. One was responsible for running the experiment and deliver instruction to subjects. Another experimenter controlled the whole system.

CHAPTER VII

EYE MOVEMENT STUDY -- RESULTS

A series of t-tests was performed to explore the differences of eye movements in the search tasks between two groups. Since the task nature of two object-search tasks was the same, the analyses of two object-search tasks would be combined. The nature of letter Z search task was different from that of letter D search task. As distinct features might facilitate searching letter D among other angular letters, the task was expected to be easier than searching letter Z. The analyses of two letter-search tasks were conducted separately.

Age and IQ

There was no significant difference between two groups on their age and non-verbal intelligence in terms of Raven's scores. (See Table 14)

Number of Objects Found in Object Search Tasks

All the subjects were able to name the target letters and objects and to locate the target letters successfully and correctly. For the object search tasks, the average number of objects found were 4.29 (40.9%) and 4.66 (44.4%) for autistic and control group respectively. No significant difference was revealed between these two groups. (See Table 15)

Total Number of Fixations

Concerning the total number of fixations including those located inside and outside the screen, there were no significant differences between two groups in all search tasks. (See Table 16)

Fixation Duration

With regard to duration of all fixations, including those inside and outside screen, there were no significant group differences of the average fixation duration

Table 14

<u>Mean age and Ravens's scores of subjects participated in the eye-movement study</u>

	Autistic N=12	Control N=16	
	M (SD)	M(SD)	t-value
Age	11.7 (1.10)	12.0 (1.23)	-0.485
Raven's score	99.83 (17.08).	96.13 (15.48)	0.600

*p<0.05; **p<0.01; *** p<0.001

Table 15

Means and Standard Deviations of Total Number of Objects Found in Object Search Tasks of Autistic and Control Groups

	Autistic N = 12	Control N=16	
	M (SD)	M (SD)	t-value
Number of objects found	4.29 (1.05)	4.66 (1.06)	-0.903

*p<0.05; **p<0.01; *** p<0.001

Table 16

Mean and Standard Deviations of Total Number of Fixations of Autistic and Control Groups

	Autistic N = 12	Control N=16	
	M (SD)	M (SD)	t-value
Total Number of Fixations			
Letter D task	49.58 (39.17)	44.19 (37.54)	0.370
Letter Z task	50.83 (29.59)	57.19 (28.21)	-0.378
Object search	83.33 (39.49)	92.75 (33.70)	-0.680

*p<0.05; **p<0.01; *** p<0.001

(divided the total length of fixation duration by the total number of fixation in each task) in the tasks (See table 17). The standard deviation of the fixation duration was an indicator of the variability of the performance of the subjects in the search tasks. Results revealed that there were no significant differences in the standard deviations between the two groups in all the tasks.

<u>Distance of Fixations</u>

With reference to another measure, the average distance among fixations (calculated from dividing the total distance by the number of fixation), group differences were shown in all tasks except the letter Z search task. The average distance of fixations in autistic group was significantly longer than those in the control group [t=4.429, p<0.001 for letter D task, t=3.636, p<0.01 for object-search task] (See table 18)

<u>Fixations Located Outside the Screen</u>

The EyeLink system recorded the locations of fixations including those outside the screen. The percentage of the number of fixations outside the screen was calculated from dividing the number of fixations outside the screen by the total number of fixations. Compared this variable on two groups, the values of autistic group were significantly greater that those of control group in all tasks. [t=2.341, p<0.05 for letter D task; t=2.207, p<0.05 for letter Z task; t=2.552, p<0.05 for object search] (See Table 19). This implied that autistic subjects spent relatively more eye fixations on the area outside the screen than control group.

<u>Fixations Located within the Screen but Outside the Designated Areas</u>

Another parameter was the number of fixations located inside the screen but outside designated areas. For the letter-search tasks, the designated areas were defined as the imaginary-rectangular boundary containing all the letters. (See Figures

9b and 10b). For the object-search tasks, the designated areas were defined as the rectangular boundary containing all pictorial items (See Figures 11b and 12b).

Comparing the percentage of fixations located within the screen and outside the designated areas of two groups, autistic group had significantly higher percentage than the control group among all tasks. [$t = 2.490$, $p<0.05$; $t = 2.298$, $p<0.05$; $t = 5.090$, $p<0.001$ for letter D task, letter Z task and object-search task respectively]. (See Table 20)

Number of Fixations Located Inside the Designated Areas

Compared the percentage of the number of fixations inside the designated areas in two groups, autistic subjects had significantly lower percentage of fixations than control group in all tasks. [$t=-4.300$, $p<0.01$ for letter D task; $t=-3.320$, $p<0.01$ for letter Z task; $t=-5.649$ for object-search task] (See table 21).

Table 17

Means and Standard Deviations of Average Fixation Duration and Standard Deviations of Autistic and Control Groups

	Autistic N = 12	Control N=16	
	M (SD)	M (SD)	t-value
Average fixation duration			
Letter D task	266.69 (57.95)	251.57 (70.98)	0.602
Letter Z task	270.96 (38.24)	245.32 (47.03)	1.543
Object search	319.80 (68.67)	292.80 (36.98)	1.234
Standard deviations of fixation duration			
Letter D task	171.95 (77.66)	134.03 (49.09)	1.581
Letter Z task	129.91 (29.95)	128.21 (51.63)	0.102
Object search	224.07 (58.22)	195.61 (42.55)	1.497

*p<0.05; **p<0.01; *** p<0.001

Table 18

Mean and Standard Deviations of Average Distance between Fixations of Autistic and Control Groups

	Autistic N = 12	Control N=16	
	M (SD)	M (SD)	t-value
Average distance between fixations			
Letter D task	123.74 (25.82)	86.89 (18.28)	4.429***
Letter Z task	96.99 (26.79)	83.86 (17.05)	1.584
Object search	99.42 (15.37)	81.26 (11.11)	3.636**

*p<0.05; **p<0.01; *** p<0.001

Table 19

Mean and Standard Deviations of Percentage of Number of Fixations Located Out of Screen of Autistic and Control Groups

	Autistic	Control	
	M (SD)	M (SD)	t-value
Percentage of number of fixations located out of the screen			
Letter D task	28.27 (40.66)	0.735 (2.941)	2.341 *
Letter Z task	24.31 (37.68)	0.296 (0.973)	2.207 *
Object search	10.24 (11.50)	1.577 (2.82)	2.552 *

* $p<0.05$; ** $p<0.01$; *** $p<0.001$

Table 20

Means and Standard Deviations of the Percentages of Fixations Located Within the Screen but Outside the Designated Areas of Autistic and Control Groups

	Autistic N = 12	Control N=16	
	M (SD)	M (SD)	t-value
Percentage of number of fixations located outside the designated area and inside the screen			
Letter D task	27.26 (29.93)	5.122 (8.35)	2.490 *
Letter Z task	18.76 (17.38)	6.513 (10.77)	2.298 *
Object search	44.94 (25.50)	6.928 (5.40)	5.090***

*p<0.05; **p<0.01; *** p<0.001

Table 21

Means and Standard Deviations of the Percentages of Number of Fixations Inside the Designated Area of Autistic and Control Groups

	Autistic N = 12	Control N=16	
	M (SD)	M (SD)	t-value
Percentage of number of fixations located inside the designated area			
Letter D task	44.47 (39.17)	94.14 (9.43)	-4.300**
Letter Z task	56.93 (36.67)	93.19 (10.76)	-3.320**
Object search	44.82 (28.18)	92.26 (8.34)	-5.649***

*p<0.05; **p<0.01; *** p<0.001

CHAPTER VIII

EYE-MOVEMENT STUDY -- DISCUSSION

Implications of Eye-Movement Patterns

Results revealed that there were no differences between two groups on the total number of fixation and average fixation duration in performing search tasks. However, autistic subjects tended to spend relatively more time to scan the areas out of screen or out of the designated areas than the control group. The distance between fixations of autistic subjects was longer than that of control ones. The results suggested that the eye-fixations were spread out and scattered, and less confined within the designated areas. It implies that the scanning patterns of autistic children tend to be more "diffuse" and less able to sustain their fixations within an area. Based on the behavioral observations of subjects, it was reported that most of normal controls were able to maintain fixations around the point on which were instructed to focus during the process of calibration. Nevertheless, some autistic children were found to have difficulties in focusing on the point. Even though they claimed that they were "looking" at that point, they actually scanned that point briefly and then moved away. Behavioral observations appeared to be consistent with the results that autistic subjects were less able to maintain their focuses or fixations around the designated points or areas.

The present findings are congruent with O'Connor and Hermelin's (cited in Litrownik & Mclnnis, 1982) which suggest that autistic children are less likely to attend to external information by focusing on it and thus they have less information available for subsequent processing. With improved precision in the instrument for recording the eye-movements, the present study further confirms the deficits of autistic children in the scanning process.

Possible Explanations for Eye-Movement Patterns

There are several possible explanations to account for the phenomenon of the eye movement pattern specific to autistic children. Having difficulty to direct the attention may be an account for the phenomenon. It is suggested that autistic children have more difficulties allocating or directing their attentions to the designated areas or information. Their attention might frequently shift. Since it is evident that autistic children was unable to maintain fixations, it is proposed that poorly sustained attention might be the second explanation. It is believed that the major deficit of the information processing of autistic children is unable to sustain attention to the designated areas or information. The above two hypotheses are not mutually exclusive. Based on these two interpretations, it is inferred that autistic children would have poor performance in the tasks which involves directing attention and/or sustaining attention to designated areas or points. Finally, motivation might be one of the possible explanations for the present phenomenon. However, since it is a relatively simple task for them to search a letter or objects, the special phenomenon of eye movement is not simply accounted for by a lack of motivation.

Speculation of Faster Information Processing

With regard to the performance of two groups on the object search tasks, autistic subject performed as well as control ones in terms of number of objects found and total fixation duration. Nevertheless, they spent relatively less proportion of total number of fixations in those designated areas than the control group. It is speculated that autistic children may process incoming information faster than control ones provided that their fixations fall on the designated area. However, the instructions of the search-tasks put greater emphasis on the number of items found rather than the time spent. The greater number of fixations displayed by the group might reflect the difference of styles in less-structural search-tasks but not the difference of speed of information processing. In addition, in the global-local processing study, although there was no significant difference in RT between two groups, there was a tendency of longer RT in the autistic group than the control among all conditions. Therefore, the present study could not strongly confirm that the autistic subjects had a faster processing of local information than control ones.

CHAPTER IX

GENERAL DISCUSSION

Possible Explanations of Global-Local Processing Findings

In the present studies, the hypothesis of lacking global precedence is partially supported. There is no evidence to support the hypothesis of perceptual span. Some negative findings might be explained by the developmental changes of global and local processing of young children or by higher susceptibility to local information.

Integrated with the findings in eye-movement study, the results of the global and local processing study are interpreted in a more comprehensive way. The findings in eye-movement study suggested that the autistic subjects tended to be less able to direct and/or maintain their focuses on the designated areas and to have diffuse fixations on the external environment. Their higher susceptibility to local information shown in the global and local processing might be related to the diffuse fixations in the registration stage of information processing. However, it is impossible to drawn any conclusions on relationship between the two phenomena merely based on the findings of the present study.

Generally, autistic subjects showed a higher percentage of errors and greater variability of RT across different conditions. Based on the results in the eye-movement study, it might be due to the inability of controlling fixations or focuses on the designated areas. Although they were instructed to focus on the fixation point, autistic subjects might be less able to focus on the stimuli presented rapidly. Without attending to the stimuli, autistic subjects were provided with less information to make accurate responses. This might induce more error and greater variability in giving responses.

Relations to the Weak Central Coherence Theory

Shown in the eye-movement study, autistic children were found to have different perception or attention from the normal control. From the global-local processing study, it was evident that autistic subjects were not only interfered by local information, but also benefited from local elements that were identical with global structure in terms of reaction time in the hierarchical patterns. Both studies suggest that the talent or deficit of autistic children lies on the more fundamental level of information processing.

Based on findings of the present study, the weak central coherence theory can be more precisely re-defined to describe the characteristic of information processing of autistic children. The weak central coherence states that autistic individuals tend to have relatively local information processing rather than a wholistic information processing and to ignore the contextual information. The present study has found that there might be a way to describe the characteristics of autistic children more precisely. It is proposed that autistic children may have both wholistic and local information processing that is the same as normal ones when encountering information in hierarchical relationship. However, they may have a higher tendency to be affected by local information. According to findings in the eye-movement study, autistic children are probably less able to direct and/or maintain their fixations on the designated areas and have "diffuse" fixations. It is speculated that autistic children may perceive external environment as visually disorganized. They may be more frequently/heavily affected by local information and may have more difficulties perceiving global and meaningful information on a higher level based on the "diffused" incoming information.

Autistic subjects are known to detect minor changes in the environment more quickly than normal ones and easily upset by those small deviation from daily routine (cited in Motton & Belleville, 1993). These peculiar characteristics of autistic people are consistent with the interpretations in the present study. Autistic children tend to have discrete fixations on the environment. Based on this interpretation, it is predicted that autistic people might have superior performance in the tasks involving part by part matching but not tracing the meaningful wholes. The present findings are also consistent in the respect of explaining the superior performance of autistic individuals in the block design, which has great demand on matching of pieces rather than whole perception. However, the previous studies of Embedded Figure Test (EFT) did not have unanimous findings.

Leung (1999) found that the autistic children had poor performance in performing the adult version of EFT than normal controls. However, it is found that autistic children have superior performance in children version of EFT (Jolliffe & Baron-Cohen, 1997). The different nature of the children version and adult version of EFT and developmental changes of perception in normal subjects are important for determining the outcomes of studies. Although performing EFT, either in adult or child versions, appears to demand the ability of disembedding simple figures from complex ones, it also requires the ability of tracing the simple figures without being affected by other distracted lines. The latter is actually the deficit of autistic children. The normal controls could be interfered by the meaningful complex figure in the children version but benefit from the meaningful descriptions of the simple target figures in the adult version. Therefore, the results are inconsistent with studies using EFT.

In conclusion, the performance of autistic children in certain tasks depends on whether those tasks tap on the talents or deficits of autistic children and normal children. Autistic children may have difficulty directing and/or maintaining fixations on essential visual information and may be more susceptible to local information.

Based on the present findings, autistic children are expected to benefit from simpler, more structural and organized visual stimuli and external environment, so that they can receive the information more effectively and less distracted by irrelevant local information.

Limitations and Suggestions

There are several limitations in the present studies. Since the target groups in the present studies were children, the interpretation of the results and conclusion might only be made in a limited extent of young age owing to the proposed effect of developmental trends on global-local processing.

Concerning the global and local processing study, the information processing of global and local information with hierarchical relationship was investigated. However, the present study could not confirm the global and local processing of non-hierarchical patterns or of focal-contextual relationship.

The children in control group were shown to process local and detailed information as fast as global information. This was not expected in normal adult when the hypothesis was formulated. The manipulations in the experiment could not significantly differentiate two groups. It might be that the difference of two groups on the global-local processing was not so obvious and distinct in the early developmental state. Therefore, it might be necessary to replicate the experiment in autistic adults and to match the control group. The developmental changes in global-local processing of two groups might be clearly shown in the future study. The deficit or characteristic of autistic adult different from normal group might be revealed.

Since the experiment does not appear to clearly differentiate the performance difference between two groups, it is suggested that the global and local study could be replicated to verify the global precedence hypothesis again solely by increasing the number of trials in each condition. Therefore, the reliability of the experiment might be improved.

As for the eye-movement study, there are several suggestions for improving the study. Firstly, in order to further investigate the hypothesis of faster input of information of autistic children, a simple task with more emphasis on the reaction time in the instruction and procedure should be given, so that the factor of processing time can be more accurately compared. Secondly, more structural and simpler tasks, such as simple reaction task, target detection or response inhibition tasks, could be employed to further confirm the deficit of autistic individuals in eye movement patterns, on the condition that the motivation factor is ruled out. The process of eye movement should be recorded by the Eye-link system.

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測驗指引

(Global to local instruction)

整個測驗分兩部份, 宜家先介紹第一部份。一陣間將會有 D 圖案係電腦螢光幕上面好快咁出現。D 圖案係由一 D 細既英文字母組成一個大既英文字母。我想你留心 D 睇下大既字母係嘜野, 係"H"定係"S", 係"H"就按呢個制 (指住個制), 係"S"就按另一個制 (指住個制) 。

我地先試一次慢慢地睇下 D 圖案。你先將個頭托係呢度 (指住 Headrest), 將食指放係兩個制上面。準備好未? 準備好就開始! 每次你都會先見到一粒星星係螢光幕中間出現, 你每次都要留心望住粒星, 然後星星好快會消失, 一頁"魚網"會出現, 你唔須要理會佢, 繼續注意螢光幕。當呢頁"魚網"消失之後, 一個咁既圖案會出現, 呢個圖案係由一 D 細既英文字母組成一個大既英文字母, 我想你淨係留意大既英文字母。我想你睇到之後, 就盡快按個個制。喇, 你宜家話比我聽大既字母係"H"定係"S"(等待回應)。
(如果正確, 就說"啱");
(如果錯誤,則說"唔啱 , 應該係___") 。

你睇到大既字母就儘快按正確既制, 宜家你應該按邊個制呀? (等待回應)。
(如果正確, 就說"啱");
(如果錯誤,則說"唔啱 , 應該係呢個制)

當你按完制之後, 塊魚網會再次出現, 你都係唔駛埋佢, 佢會消失, 咁就係做完一次。隔一陣粒星星會再次出現, 你就要望住佢, 之後會重覆先前既次序: 星星, 魚網, 圖案, 儘快按制, 魚網會再出現。D 圖案會連續咁出現, 有 D 會大 D, 有 D 會細 D, 你都一樣好似頭先咁樣做。明白未?有沒有問題?

我地先試幾個, 呢次 D 圖案會出得好快, 你要留心 D 睇住, 記住要睇大既圖案。你先將頭托係呢度, 將食指放係制上面。準備好未? 記住要又快又準咁按制, 準備好就開始!

(完成後) 係喇! 就係咁做。
宜家正式開始!
(休息 5 秒) 預備繼續。
(完成第一部份) 你頭先做得好好。第一部份完成啦。可以休息一陣。(30 秒)

跟住做第二部份，呢一部份同頭先差唔多， 會先出星星，魚網，圖案，魚網，不過，你今次我想你留意<u>細既</u>字母，大既字母就唔駛理會，見到邊個字母就按個個制，明白未?

我地先試一次慢既。你先將個頭托係呢度 (指 Headrest)，將食指放係兩個制上面。你會先見到星星，魚網，一個咁既圖案，記住你淨係留意<u>細既</u>英文字母，你宜家話比我聽細既字母係"H"定係"S"(等待回應)。
(如果正確，就說"啱");
(如果錯誤,則說"唔啱，應該係___") 。

咁宜家你應該按邊個制呀? (等待回應)。
(如果正確，就說"啱");
(如果錯誤,則說"唔啱，應該係呢個制)
塊魚網會再次出現。跟住星星，魚網，圖案，儘快按制，魚網會接住出現。

我地先試幾個，呢次 D 圖案會出得好快，你要留心 D 睇住，記住要睇<u>細既</u>字母。你先將頭托係呢度，將食指放係制上面。準備好未? 記住要<u>又快又準</u>咁按制，準備好就開始!

(完成後) 係喇! 就係咁做。
宜家正式開始!
(休息 5 秒) 預備繼續。
(完成第二部份) 你做得好好。整個測驗做完。

測驗指引

(Local to Global instruction)

整個測驗分兩部份，宜家先介紹第一部份。一陣間將會有 D 圖案係電腦螢光幕上面好快咁出現。D 圖案係由一 D 細既英文字母組成一個大既英文字母。我想你留心 D 睇下<u>細既</u>字母係咩野，係"H"定係"S"，係"H"就按呢個制 (指住個制)，係"S"就按另一個制 (指住個制) 。

我地先試一次慢慢地睇下 D 圖案。你先將個頭托係呢度 (指住 Headrest)，將食指放係兩個制上面。準備好未? 準備好就開始! 每次你都會先見到一粒星星係螢光幕中間出現，你每次都要留心望住粒星，然後星星好快會消失，一頁"魚網"會出現，你唔須要理會佢，繼續注意螢光幕。當呢頁"魚網"消失之後，一個咁既圖案會出現，呢個圖案係由一 D 細既英文字母組成一個大既英文字母，我想你淨係留意<u>細既</u>英文字母。我想你睇到之後，就盡快按個個制。喇，你宜家話比我聽大既字母係"H"定係"S"(等待回應)。
(如果正確，就說"啱");
(如果錯誤,則說"唔啱，應該係___") 。

你睇到大既字母就儘快按正確既制，宜家你應該按邊個制呀? (等待回應)。
(如果正確，就說"啱");
(如果錯誤,則說"唔啱，應該係呢個制)

當你按完制之後，塊魚網會再次出現，你都係唔駛理佢，佢會消失，咁就係做完一次。隔一陣粒星星會再次出現，你就要望住佢，之後會重覆先前既次序: 星星，魚網，圖案，儘快按制，魚網會再出現。D 圖案會連續咁出現，有 D 會大 D，有 D 會細 D，你都一樣好似頭先咁樣做。明白未?有沒有問題?

我地先試幾個，呢次 D 圖案會出得好快，你要留心 D 睇住，記住要<u>細既</u>既圖案。你先將頭托係呢度，將食指放係制上面。準備好未? 記住要<u>又快又準</u>咁按制，準備好就開始!

(完成後) 係喇! 就係咁做。
宜家正式開始!
(休息 5 秒) 預備繼續。
(完成第一部份) 你頭先做得好好。第一部份完成啦。可以休息一陣。(30 秒)

跟住做第二部份，呢一部份同頭先差唔多， 會先出星星，魚網，圖案，魚網，不過，你今次我想你留意<u>大既</u>字母，大既字母就唔駛理會，見到邊個字母就按個個制，明白未？

我地先試一次慢既。你先將個頭托係呢度 (指 Headrest)，將食指放係兩個制上面。你會先見到星星，魚網，一個咁既圖案，記住你淨係留意<u>大既</u>英文字母，你宜家話比我聽細既字母係"H"定係"S"(等待回應)。
(如果正確，就說"啱")；
(如果錯誤,則說"唔啱，應該係___") 。

咁宜家你應該按邊個制呀？(等待回應)。
(如果正確，就說"啱")；
(如果錯誤,則說"唔啱，應該係呢個制)
塊魚網會再次出現。跟住星星，魚網，圖案，儘快按制，魚網會接住出現。

我地先試幾個，呢次 D 圖案會出得好快，你要留心 D 睇住，記住要睇<u>大既</u>字母。你先將頭托係呢度，將食指放係制上面。準備好未？ 記住要<u>又快又準</u>咁按制，準備好就開始！

(完成後) 係喇！ 就係咁做。
宜家正式開始！
(休息 5 秒) 預備繼續。
(完成第一部份) 你做得好好。整個測驗做完。

Eye-Link Experiment Instruction (letter => object search)

Step 1: Run the program

C:/ (*type* cd exp ↵)

C:/EXP (*type* pcxscr [*file name*].scr [*data file name*] ↵)

Note: There are eight files stored in the computer for different combinations of the sequence of display materials. Please refer to the record sheet for the file name and date file name assigned.

(8 file names: L12P12.scr; L12P21.scr; L21P12.scr; L21P21.scr; P12L12.scr; P12L21.scr; P21L12.scr; P21L21.scr)

Step 2: Calibration of the eye link

呢個測驗會分兩部份，我地先做第一部份。

(Part 1: Letter search)

你將會係電腦螢光幕中間見到一個英文字母，我想你留心 D 睇，然後記住佢。過一陣間佢會消失，然後會出現幾行英文字母，你要由第一行開始，由左至右，一行跟住一行，搵出你最初見到個個字母，搵到就話俾我知。明唔明白?

(當字母出現）宜家開始，記住呢個字母。

(PRESS THE KEY ONCE)

(當字母消失，黑點出現）望住粒黑色既豆豆。

(當幾行字母出現）搵到你頭先見到個個字母，就話俾我知。

你頭先做得好，我地做多一次。好似頭先咁做。由第一行開始，由左至右，一行跟住一行，搵出個字母。

(PRESS THE KEY ONCE)

(當字母出現)宜家開始，記住呢個字母。

(PRESS THE KEY ONCE)

(當字母消失，黑點出現）望住粒黑色既豆豆。

(當幾行字母出現）搵到頭先見到個個字母，就話俾我知。

好喇，做完第一部份。

(Part 2: Object Search)

第二部份同第一部份差唔多，係電腦螢光幕中間會出現一件物件既圖片，我

想你留心D睇，然後記住佢。過一陣間佢會消失，然後會出現一幅圖畫，裏面收埋左好多你頭先見到個件物件，不過未必係一模一樣，有D只係得一部份，有D個樣有D唔同，你要儘量搵曬佢地出黎，數下有幾多個，然後話俾我知。明唔明白？

(PRESS THE KEY ONCE)
(當物件出現) 宜家開始，記住呢件物件。
(PRESS THE KEY ONCE)
(當物件消失，黑點出現) 望住粒黑色既豆豆。
(當出現一幅圖畫) 當搵曬次後，就話俾我知有幾多個。(Record the result)

你頭先做得好，我地做多一次。好似頭咁做。儘量搵曬件物件出黎。
(PRESS THE KEY ONCE)
(當物件出現) 宜家開始，記住呢件物件。
(PRESS THE KEY ONCE)
(當物件消失，黑點出現) 望住粒黑色既豆豆。
(當出現一幅圖畫) 當搵曬次後，就話俾我知有幾多個。(Record the result)

好喇，做完曬啦。

Eye-Link Experiment Instruction (Object =>letter)

Step 1: Run the program

C:/ (*type* cd exp ↲)

C:/EXP (*type* pcxscr [*file name*].scr [*data file name*] ↲)

Note: There are eight files stored in the computer for different combinations of the sequence of display materials. Please refer to the record sheet for the file name and date file name assigned.

Step 2: Calibration of the eye link

呢個測驗會分兩部份，我地先做第一部份。

(Part 1: Object Search)

你將會係電腦螢光幕中間見到一件物件既圖片，我想你留心 D 睇，然後記住佢。過一陣間佢會消失，然後會出現一幅圖畫，裏面收埋左好多你頭先見到個件物件，不過未必係一模一樣，有 D 只係得一部份，有 D 個樣有 D 唔同，你要儘量搵曬佢地出黎，數下有幾多個，然後話俾我知。明唔明白?

(當物件出現）宜家開始，記住呢件物件。
(PRESS THE KEY ONCE)
(當物件消失，黑點出現）望住粒黑色既豆豆。
(當出現一幅圖畫）當搵曬次後，就話俾我知有幾多個。(Record the result)

你頭先做得好，我地做多一次。好似頭咁做。儘量搵曬件物件出黎。
(PRESS THE KEY ONCE)
(當物件出現）宜家開始，記住呢件物件。
(PRESS THE KEY ONCE)
(當物件消失，黑點出現）望住粒黑色既豆豆。
(當出現一幅圖畫）當搵曬次後，就話俾我知有幾多個。(Record the result)

好喇，做完曬啦。

(Part 2: Letter search)

第二部份同第一部份差唔多， 你將會係電腦螢光幕中間見到一個英文字母，

我想你留心D睇，然後記住佢。過一陣間佢會消失，然後會出現幾行英文字母，你要由第一行開始，由左至右，一行跟住一行，搵出你最初見到個個字母，搵到就話俾我知。明唔明白?

(PRESS THE KEY ONCE)
(當字母出現) 宜家開始，記住呢個字母。
(PRESS THE KEY ONCE)
(當字母消失，黑點出現) 望住粒黑色既豆豆。
(當幾行字母出現) 搵到你頭先見到個個字母，就話俾我知。

你頭先做得好，我地做多一次。好似頭咁做。由第一行開始，由左至右，一行跟住一行，搵個字母出黎。

(PRESS THE KEY ONCE)
(當字母出現)宜家開始，記住呢個字母。
(PRESS THE KEY ONCE)
當字母消失，黑點出現) 望住粒黑色既豆豆。
(當幾行字母出現) 搵到頭先見到個個字母，就話俾我知。
好喇，做完囉啦。

Appendix 3

Mean and Standard Deviations of Reaction Time for Group (Autistic vs. Control), Instruction (Global-directed vs. Local-directed), Size (Small vs. Large) and Exposure Duration (65ms vs. 130 ms.) and Stimuli (Consistent vs. Neutral vs. Conflicting)

Control Group

	Small		Large	
	65 msec.	130 msec.	65 msec.	130 msec.
	M(SD)	M(SD)	M(SD)	M(SD)
Global directed				
Consistent	657.96(35.26)	642.13(37.76)	644.60(37.04)	634.10 (29.03)
Neutral	686.29(49.35)	681.33(37.95)	658.17(35.00)	654.44(37.48)
Conflicting	761.96(47.33)	698.55(33.68)	681.68(34.06)	742.38(33.58)
Local directed				
Stimuli				
Consistent	629.33(40.04)	610.51(38.37)	602.05(34.44)	596.26(36.50)
Neutral	606.28(39.84)	603.30(36.82)	585.75(36.64)	628.59(39.86)
Conflicting	687.50(48.43)	665.52(45.10)	658.97(45.60)	652.09(43.60)

Autistic Group

	Small		Large	
	65 msec.	130 msec.	65 msec.	130 msec.
	M(SD)	M(SD)	M(SD)	M(SD)
Global-directed				
Consistent	682.62(38.47)	652.21(41.20)	651.75(40.41)	633.68(31.67)
Neutral	798.80(53.84)	687.64(41.40)	718.14(38.19)	733.42(40.89)
Conflicting	792.50(51.64)	745.91(36.75)	736.21(37.17)	740.60(36.74)
Local-directed				
Consistent	693.39(43.69)	686.88(41.57)	624.81(37.58)	677.10(39.83)
Neutral	704.87(43.47)	719.83(40.18)	686.13(39.99)	683.64(43.50)
Conflicting	770.95(52.84)	742.53(49.20)	731.85(49.75)	743.96(47.57)

Appendix 4

Mean and Standard Deviations of Percentage of Error for Group (Autistic vs. Control), Instruction (Global-directed vs. Local-directed), Size (Small vs. Large) and Exposure Duration (65ms vs. 130 ms.) and Stimuli (Consistent vs. Neutral vs. Conflicting)

Control Group

	Small		Large	
	65 msec.	130 msec.	65 msec.	130 msec.
	M(SD)	M(SD)	M(SD)	M(SD)
Global directed				
Consistent	0.208(0.110)	0.167(0.106)	0.083(0.094)	0.250(0.100)
Neutral	0.458(0.171)	0.208(0.098)	0.292(0.124)	0.292(0.137)
Conflicting	0.625(0.239)	0.417(0.210)	0.417(0.182)	0.583(0.199)
Local directed				
Stimuli				
Consistent	0.208(0.165)	0.250(0.143)	0.250(0.136)	0.208(0.119)
Neutral	0.083(0.147)	0.083(0.118)	0.208(0.126)	0.292(0.114)
Conflicting	0.542(0.168)	0.250(0.115)	0.375(0.134)	0.250(0.130)

Autistic Group

	Small		Large	
	65 msec.	130 msec.	65 msec.	130 msec.
	M(SD)	M(SD)	M(SD)	M(SD)
Global-directed				
Consistent	0.333(0.110)	0.292(0.106)	0.208(0.094)	0.250(0.100)
Neutral	0.458(0.171)	0.250(0.098)	0.417(0.124)	0.375(0.137)
Conflicting	1.083(0.239)	1.000(0.210)	0.792(0.182)	1.125(0.199)
Local-directed				
Consistent	0.583(0.165)	0.458(0.143)	0.375(0.136)	0.375(0.119)
Neutral	0.417(0.147)	0.333(0.118)	0.333(0.126)	0.333(0.114)
Conflicting	0.750(0.168)	0.458(0.115)	0.417(0.134)	0.500(0.130)

Appendix 5

Mean and Standard Deviations of Variability of RT for Group (Autistic vs. Control), Instruction (Global-directed vs. Local-directed), Size (Small vs. Large) and Exposure Duration (65ms vs. 130 ms.) and Stimuli (Consistent vs. Neutral vs. Conflicting)

Control Group

	Small		Large	
	65 msec.	130 msec.	65 msec.	130 msec.
	M(SD)	M(SD)	M(SD)	M(SD)
Global directed				
Consistent	121.62(20.07)	106.24(16.48)	126.70(15.91)	121.32(21.42)
Neutral	127.78(20.94)	143.96(27.03)	120.28(19.32)	88.98(12.04)
Conflicting	171.74(30.17)	120.27(12.94)	109.80(21.89)	165.56(23.52)
Local directed				
Stimuli				
Consistent	121.74(27.26)	127.76(17.87)	105.96(18.65)	103.51(18.23)
Neutral	124.14(14.64)	126.38(14.95)	129.73(15.44)	118.64(17.67)
Conflicting	165.05(23.95)	155.39(21.75)	146.33(17.70)	164.33(22.34)

Autistic Group

	Small		Large	
	65 msec.	130 msec.	65 msec.	130 msec.
	M(SD)	M(SD)	M(SD)	M(SD)
Global-directed				
Consistent	148.08(24.31)	170.74(19.95)	146.18(19.28)	178.68(25.94)
Neutral	191.05(25.36)	122.26(32.74)	143.41(22.18)	153.69(14.58)
Conflicting	171.93(36.53)	139.09(15.67)	162.93(26.51)	138.78(28.49)
Local-directed				
Consistent	173.32(33.02)	139.06(21.64)	151.73(22.59)	158.97(22.08)
Neutral	140.79(17.74)	125.67(18.10)	121.30(18.70)	148.04(21.39)
Conflicting	206.75(29.01)	146.87(26.34)	159.50(21.44)	137.35(27.06)